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1.

MODERN
Electrical Construction

A RELIABLE, PRACTICAL GUIDE FOR THE BEGINNER IN ELECTRICAL CONSTRUCTION SHOWING THE LATEST APPROVED METHODS OF INSTALLING WORK OF ALL KINDS ACCORDING TO THE SAFETY RULES OF THE

National Board of Fire Underwriters

By

HENRY C. HORSTMANN

and

VICTOR H. TOUSLEY

Authors of "Modern Wiring Diagrams and Descriptions" Electrical Wiring and Construction Tables," "Practical Armature and Magnet Winding," "Electricians Operating and Testing Manual," Etc.

Illustrated

FIFTH EDITION—REVISED AND ENLARGED

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PREFACE

In this volume an attempt is made to provide the beginner in electrical construction work with a reliable, practical guide; one that is to tell him exactly how to install his work in accordance with the latest approved methods.

It is also intended to give such an elaboration of "safety rules" as shall make the book valuable to the finished workman as well. To this end the rules of the "National Electrical Code" of the National Board of Fire Underwriters have been given in full, and used as a text in connection with which there is interspersed in the proper places a complete explanation of such work as the rules may apply to. This method of teaching and explaining practical electricity may at first glance seem somewhat haphazard, but it resembles very closely the actual method by which the most successful, practical workmen have learned the trade. It is thought that explanations pertaining directly to the work in hand will be more deeply considered and more likely to be fully comprehended than explanations necessarily more abstract.

It should be noted that, while the rules published in the "National *Electrical* Code" are standard and work done in

conformity with them will be first-class, several of the larger cities have ordinances governing electrical work which conflict in some details with these rules. Workers in such cities should, therefore, provide themselves with copies of these ordinances (usually obtainable without charge), and compare them with the rules given in this work. It is necessary for the electrical worker at all times to keep himself posted, for safety rules are liable to change.

The tables concerning screws, nails, number of wires that can be used in conduit, etc., are especially prepared for this volume, and give to it particular value for practical men.

THE AUTHORS.

PREFACE TO SECOND EDITION

The favorable reception which the first edition of this work has received at the hands of electrical workers generally has induced the authors to prepare this, the Second Edition. Considerable new matter, notably a section on Theater Wiring, has been added. All the necessary alterations and additions have been made in the text to conform to the latest issue of the National Code, together with the required explanations and illustrations. Other sections have been extended and the whole work has been carefully gone over and revised wherever the progress of the art has made it desirable.

THE AUTHORS.

PREFACE TO THE THIRD EDITION

In a work of this kind it is of prime importance that it be kept abreast of the times. Safety rules are liable to change, in fact must do so to adapt themselves to the steadily increasing number of new inventions and devices brought upon the market.

This work having found sufficient favor in the eyes of many instructors to warrant its adoption as a text-book, is to be revised and new matter added as often as notable changes in methods of construction or safety rules make it appear desirable.

The latest additions and modifications of the "National Electrical Code" are contained in an appendix which should be consulted. New illustrations are inserted in the body of the work as needed.

THE AUTHORS.

PREFACE TO FOURTH EDITION

The favor with which former editions of this work have been received and the general reliance placed upon it by electrical workers everywhere has made it practically mandatory that it be kept strictly up-to-date. Since the National Electrical Code is subject to bi-ennial revision a similar revision of this work is advisable and it is the purpose hereafter to provide such. This work consists really of two parts, one being a literal transcription of the National Electrical Code, and the other consisting of comments and practical hints by the authors with the object of instructing wiremen in the installation of electrical apparatus.

While long experience has given the authors a peculiar fitness to speak upon the matters considered, it is, nevertheless, thought advisable to warn the reader that on all points that may not seem perfectly clear and harmonious it is best to consult the inspection department having jurisdiction; in other words, the authors wish distinctly to waive all claims to speaking officially on any part of the Code.

It has been the aim of the authors to treat every branch of electrical construction work which may come under the supervision of a practical wireman and for this reason a chapter on electric sign hanging and some notes on moving picture booths and installations have been added.

This work deals only with construction. Should any wireman be called upon to advise in the layout of lighting installations much information of a useful and practical nature will be found in a recent work entitled "Modern Illumination, Theory and Practice" which may be considered as supplementary to this work.

THE AUTHORS.

CHAPTER I.

The Electric Current.

It is quite customary and convenient to speak of that agency by which electrical phenomena, such as heat, light, magnetism, and chemical action are produced as the electric current. In many ways this current is quite analogous to currents of air or water. Just as water tends to flow from a higher to a lower level, and air from a region of greater density or pressure to one of lesser density, so do currents of electricity flow from a region of high pressure to one of low pressure. Currents of electricity form no exception whatever to the general law of all action, which is along the lines of least resistance. It must not be understood, however, that electricity actually flows in or along a conductor, as water does in a pipe, and the analogy must not be carried too far, for the flow of water in pipes is influenced by many conditions which do not influence a flow of electricity at all, and vice versa; there are conditions surrounding conductors, which influence the flow of electricity which do not affect the flow of water.

Above all, let it be understood that electricity is not independent energy, any more than the belt which gives motion to a pulley is. In other words, it is not a prime mover, it is simply a medium which may be used for the transmission of energy, just as the belt is used. To use electricity as a medium for the transmission of energy, it must be, we may say, compressed, or, to use a more properly technical expression, a difference of potential or pressure must be created in a system *of conductors.* This is very similar to the use of air

for power transmission; this must also be compressed so t
a difference of pressure exists within a system of piping.

It is the flow of electricity or air which takes place w
switches or valves are operated and which tends to equa
this pressure, i. e., flow from high to low pressure, that
our work. The real energy, however, (so far as we are
cerned), to which we must look for our initial motion
either case is derived from the coal which generates ste
or, in the case of water-driven machinery, the rays of the
which evaporate water, allowing it to be carried to hig
levels, from whence it flows downward over dams and
on its way back to the lowest level. In the battery, the
energy is that of chemical action, which is transformed
electrical energy.

The flow of current can take place only in a systen
conductors which usually, for convenience, are made in
form of wires. The current for practical purposes may
considered as flowing along such wires only. It is not, h

Figure 1

ever, necessary that these wires should be of any partic
size, or consist all of the same material. In an electric
tery, part of the circuit consists of the liquid contained wi
the battery; the rest being made up usually of wire. In
incandescent light circuit part of the circuit consists of

lamp filament (usually carbon), while the balance of the circuit consists of copper wire.

The flow of current is also said to have a certain direction; that is, it is noticed that many of its effects are reversed when the terminals of the battery are reversed. Referring to Fig. 1, which shows a battery of three cells, the current flows from the copper element at bottom of jar 1, along the wire to the zinc element at top of jar 2, thence through the liquid to the copper element at bottom of jar 2, and from there to the zinc at top of jar 3, etc., and finally through the wire *a* back to the starting point. Within the battery the current flows from the zinc to the copper and the decomposition of the zinc generates the current. In the wire outside of the battery the current flows from the copper to the zinc as indicated by arrows. The combination of battery and wire is known as an electric circuit. The current will flow in this circuit only while it is complete, that is while each wire connects to its proper place as shown. If any wire is disconnected, the current flow will cease. Such a circuit is said to be *open*, but when all connections are properly made it is said to be *closed*.

Work can be obtained from a flow of current in many ways. If the current be forced to flow over a wire which is very small in proportion to the current carried, it will be heated thereby and finally melted if the current is excessive. This is how electric light is obtained.

If a wire carrying current be wound many times about an iron bar this bar becomes a magnet; that is, while the current is flowing around it, the bar has the power to attract other objects of iron or steel. The bar if made of well annealed iron will be a magnet while current is flowing around it, but will cease to be magnetic whenever the current flow ceases. Upon this fact the operation of electric bells, telegraph instruments and motors is based.

If a *current of electricity* flow through a properly arranged

"bath," one of the plates will be gradually consumed and the other increased in weight. This effect is made use of in electro-plating, etc. If the jar contains water slightly acidulated and the current flows through it, the water will be decomposed and oxygen and hydrogen gas will be formed. This and many kindred effects are daily used in thousands of chemical laboratories.

If a wire carrying an electric current be placed very close to another wire forming a closed circuit, a wave of current will be induced in that wire every time the current in the other is made or broken, i. e., whenever it starts to flow or stops flowing. This fact forms the basis of the alternating current transformer.

All of these facts are used sometimes together, sometimes singly in measuring the electric current.

Conductors and Insulators.

Electrically speaking, all substances are divided into two classes. They are either conductors or insulators. By this is not meant that some substances can carry no current at all, for, as a matter of fact, there is no such thing as either a perfect conductor or a pecfect insulator. A current of electricity can be forced through any substance, provided the pressure (E. M. F.) be made great enough, and there is no easier path open to the current. The two terms, conductor and insulator, are relative terms and must be understood simply to mean that the electrical resistance of a good conductor is infinitesimally small as compared to that of a good insulator. The lower the specific resistance of any substance, the better its conducting qualities; the higher the specific resistance of any substance, the better will be its insulating qualities.

At the left is given a list of good conductors, in the orde of their conductivity, the figures representing the relative con-

ductivity of these metals. A list of insulators is given at the right; all of these are more or less affected by moisture, losing their insulating qualities when wet.

Silver	100.0	Dry air.	Fiber.
Copper	94.0	Rubber.	Wood.
Gold	73.0	Paraffin.	Shellac.
Platinum	16.6	Slate.	
Iron	15.5	Marble.	
Tin	11.4	Glass.	
Lead	7.6	Porcelain.	
Bismuth	1.1	Mica.	

Pressure or Electro-Motive Force.

Currents of electricity flow only in obedience to electrical pressure. This pressure is measured and expressed in *volts*, the unit of electrical pressure being the *volt*. If we speak of water or steam pressure, we speak of it in pounds, the pound being the unit of measurement. In speaking of electrical pressure we refer to it as of so many *volts*. There is no direct connection between the pound and the volt, but each in its place means about the same thing.

The *volt* is defined as that difference of potential (pressure) that must be maintained to force a current of one *ampere* through a resistance of one *ohm*.

If we have a resistance greater than one ohm and wish to send a current of one ampere through it, we can do so by increasing the pressure or voltage, as it is termed, accordingly. The current flowing in a circuit can also be reduced by reducing the *voltage*.

The ordinary incandescent lamps operate at about 110 *volts* pressure, although some are built for 220 volts. An electric bell requires about 2½ volts (a battery of 2 cells) for proper operation.

Resistance.

We have seen that a flow of current always takes place along or in a conductor. Every conductor, no matter how large or small it may be, offers some resistance to this flow of current just as the water pipe offers more or less resistance to the flow of water. This resistance may be measured and expressed in *ohms;* the unit of electrical resistance being the *ohm*. The *ohm* is defined as that resistance which requires a difference of potential of one volt to send a current of one *ampere* through it. If we should desire to send a greater current through any resistance, we can do so by increasing the pressure, just as we can increase the flow of water in a pipe by increasing the pressure or head of water in the tank that supplies it. If the pressure is fixed we can decrease the current by using a wire of greater resistance or increase it by using wires of lesser resistance.

The *ohm* is the resistance of a column of mercury 106.2 centimeters long (about 3½ feet) and one square millimetre (about .0015 sq. in.), in cross-section, at the temperature of melting ice.

The resistance of a No. 14 copper wire about 380 feet long is equal to one ohm.

The resistance of all conductors increases directly as the

Figure 2

length and decreases as the cross-section increases. In Figure 2 the resistance of the two bars of copper is exactly equal. Bar No. 1 having a cross-section of 4 square inches and being 4 feet long, while bar No. 2 has a cross-section of only 1 square inch and is only one foot long. If bar No. 1 were

:duced to a cross-section of 1 square inch, it would become) feet long and would have a resistance 16 times as great as ıat of bar No. 2.

Current.

The electric current is the result of electrical pressure volts) acting through a resistance, and is measured in *mperes,* the *ampere* being the unit of current strength. The *mpere* is defined as that current which will flow through a :sistance of one *ohm* when a difference of potential or pres- ıre of one volt is maintained at its terminals.

The *ampere* expresses only the rate of flow, not the quan- ty. Knowing the amperes if we would know the quantity, e must multiply by the time that the rate of flow continues. he rate of flow is analogous to the speed of a train; unless e know how long the train is to maintain a certain speed, we ave no idea how far it is going.

Quantity in electricity is measured in *coulombs.* The *oulomb* is the quantity of current delivered by a flow of one mpere in one second.

Ohm's Law.

Ohm's law expresses the relation of the three principal ectrical units to each other and forms the basis of all elec- ical calculations.

This law states that in any electric circuit (with direct ırrent) the *current* equals the *electro-motive force* divided by ıe *resistance.* The current, we have already seen, is the ıedium which does our work. Current flow, we see from this ıw, can be increased either by increasing the electro-motive)rce, or electric pressure, which causes the flow; or by ecreasing the resistance which tends to prevent current flow. Expressed in symbols it is this: I=E/R; where I stands for

current, E, for electro-motive force, and R for resistance. as an example, we have an electro-motive force (which shall henceforth designate by the customary abbreviation M. F.) of 110 volts and a resistance of 220 ohms, the resul current will be 110 divided by 220 = ½ ampere, being appr mately the current used in a 16 cp. incandescent lamp at volts. Thus it will be seen that by a very simple calcul we can find the current flow in any conductor if we but k the E. M. F. and the resistance of that circuit.

This formula can also be used to find the E. M. F., i know the value of current and the resistance, since E div by R=I; I times R must equal E. If the current and re ance are known, we need only to multiply them together to the E. M. F.; I×R=E. Knowing the current and E. M we can find the value of the resistance by dividing the E F. by the current; E/I=R.

As a practical application of these formulas: If we to know how much current a certain E. M. F. can through a certain resistance, we must divide the E. M (volts) by the resistance (ohms.) If we wish to know E. M. F. (volts) will be necessary to force a certain rent (amperes) through a certain resistance, we need multiply the current (amperes) to be obtained by the re ance in ohms. If we wish to know how much resist (ohms) must be placed in a circuit to keep down the cur flow to a certain limit, we need only divide the E. M (volts) by the desired current (amperes); the result wi the value in ohms of the required resistance.

Power.

The power consumed or transmitted in an electric cuit equals the product of the volts and amperes; pres and current.

To find the power of a steam engine, we must know the pressure of the steam and the quantity used; the power contained in the water of a dam depends upon its volume and its head. The power we can obtain from the wind depends upon its speed and the surface we expose to it which also measures the quantity.

All of these cases are analogous and similar. Power expresses the rate of doing work, thus the rate of work is the same whether we are lifting one pound at the rate of 100 feet per minute, or 100 pounds at the rate of one foot per minute. The unit of electrical power is the *watt*. It is the power expended in an electric circuit when one ampere flows through a resistance of one ohm, or when a difference of potential of one volt is maintained in a circuit having a resistance of one ohm. In an electric light circuit, for instance, as far as the power is concerned, it is immaterial whether each lamp requires 110 volts and ½ ampere, or 55 volts and one ampere, or 220 volts and ¼ ampere. The power (watts) expended in an electric circuit is always equal to the volts multiplied by the amperes; thus, one ampere at 1,000 volts is equal to 100 amperes at 10 volts, or to 200 amperes at 5 volts. In any power transmission whenever the pressure (volts) is lowered, the current (amperes) must be increased or the power (watts) will fall off, and, on the other hand, whenever the pressure is increased the current may be decreased.

Instead of multiplying volts by amperes, we can find the power in an electric light circuit by multiplying the current by itself and then by the resistance; or the E. M. F. by itself and divide by the resistance.

Thus knowing the volts and the amperes, we use the formula $E \times I = W$. Knowing only the amperes and the ohms, we may *use the* formula, $I^2 \times R = W$; and lastly,

knowing only the volts and ohms, we use the form $E^2/R = W$.

In the above E stands for E. M. F., or volts; I for cu or amperes; and R for resistance or ohms.

Divided Circuits.

Currents of electricity always flow along the path least resistance just as currents of water do. Water, well known, will not flow over the top of a mill dam v

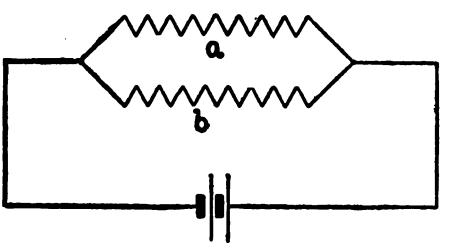


Figure 3

there is an opening alongside of it through which it can If a barrel of water be provided with two openings, large opening and one small, a much larger quantity flow out through the large opening than through the s This is because the resistance to the flow of water of large opening is so much less than the resistance of small opening.

An electric current will act in just the same way; conductor having the lesser resistance will carry the gr current. If we know the resistances of the different p open to a certain current we can determine to a nicety much current will flow in each. In Figure 3, which r sents diagramatically a battery of two cells and an ele circuit, the resistance of the two paths, *a* and *b*, is equ

0 ohms each, and the current will divide equally between hem. If the resistance of *a* were 5 ohms, and that of *b*, 0 ohms, two-thirds of the total current would pass through and the one-third through *b*.

In all such divided circuits, the current is always inersely proportional to the resistance and the simplest way o find the current in each is to add the resistances of the two ircuits; for instance as above, 5 plus 10 equals 15; now /15 of this current will flow through the 10 ohms and 10/15 f the current will flow through the 5 ohms.

To determine the combined resistance of the two wires, and *b*, we need simply to consider them as made into one wire. If they are both alike, they would, if made into one wire, be twice as large as either one is at present, and would hen have only one-half as much resistance as either one had efore; for the resistance of any conductor increases directly as its length, and decreases as the cross-section increases. The combined resistances of any two conductors can be found by multiplying their two resistances together and dividing this product by their sum. Thus, again taking the value of *a* and *b* as 10 ohms each, 10×10 equals 100, this divided by 10 plus 10 equals 5, which is the combined resistance of the two.

If we have a large number of branch circuits as shown in Figure 4, which represents diagramatically an incandescent

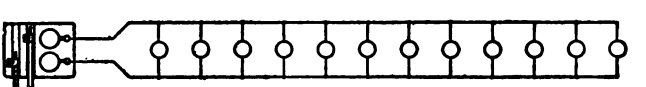


Figure 4

electric light circuit of 12 lights (which is equal to 12 separate circuits, since each lamp really forms a circuit by itself), we can find the joint resistance of the 12 by proceeding as before; that is, multiplying together the resistance of the first and

second lamp and dividing by the sum of these resistances; next take the result so obtained (which is the combined resistance of the first two lamps) and with it multiply the resistance of the third lamp and divide by the sum as before. By repeating this operation and always treating the joint resistances already found as one circuit, the joint resistance of any number of such circuits can be found. Another and a very much quicker way consists in using the following formula: The joint resistance of any number of parallel circuits is equal to the reciprocal of the sum of the reciprocals. The reciprocal of any number is 1 divided by that number. If we have three circuits, having respectively 10, 20, and 30 ohms resistance, we proceed in the following way: The reciprocal of 10 is 1/10, of 20, 1/20, etc., the joint resistance, therefore, is 1/10 plus 1/20 plus 1/30 equals 11/60, and 1 divided by this number which is 5 5/11.

These methods are only necessary when the resistances are of different values. When all of them are alike, as is usual with incandescent lights, the resistance of one lamp needs only to be divided by the number of lamps to find the joint resistance. Thus, supposing each of the 12 lamps to have a resistance of 220 ohms, the joint resistance of the circuit would be $220/12 = 18\ 1/3$.

need of the blue vitriol is shown by the fading of the blue color, which should be kept as high as the top of the copper, but should never reach the zinc.

A battery of this kind when newly set up should be short circuited for a few hours, that is, a wire should be connected from the zinc at one end of the battery to the copper at the other.

There are many styles of batteries and different chemicals are used with them. The two kinds above described are, however, the most used. The methods of connecting is in all batteries the same.

Figure 12 shows a diagram of a battery connected in series; the long thin lines represent the copper or carbon pole from which the current flows in the external circuit and the short thick lines represent the zinc from which the current flows toward the copper inside of the cell.

Figure 12

If we have a circuit of low resistance to work through and desire to increase the current, we may group our cells as shown in Figure 13, where two sets are in parallel. This arrangement will give a stronger current, but it is necessary to see that both groups of cells have the same electro-motive force; if they have not, the higher one will send the current through the lower. If the two batteries are not connected with similar poles together, they would be on short circuit, and no current could be obtained in the external circuit.

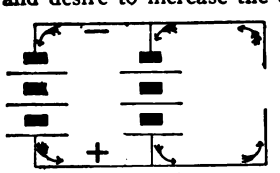


Figure 13

work is in electrical connection with B. The armature, B, is provided with contact spring S, which normally rests against the adjusting screw, C. The current now passes from the contact spring to the adjusting screw and from it to the wire wound on the magnets, M, around the many turns of wire to the binding post, D, and back to the zinc pole of the battery marked —.

The current circulating many times in the wire wound on the spools of M makes the iron cores magnetic so that they now attract the armature B. When this armature is attracted, it moves towards the magnets, M, and carries the small contact spring with it, thus breaking the connection between C and S.

This stops the current flow and the magnets, M, are at once demagnetized, thus releasing the armature B, which flies back and again closes the circuit at CS, this causes the armature to be attracted again and once more the circuit is broken. In this way the armature is made to strike the gong continuously while the circuit is kept closed at the push button. When the button is released, the circuit is permanently open and the bell at rest.

In the figure there is shown only one cell, this, if a good form is selected, is sufficient for a new bell if the circuit is not long. When, however, the bell is used much the contact points are eaten away by the little sparks occurring every time the bell breaks the circuit. Dirt is also likely to gather on them and prevent good contact being made. Both of these factors add resistance to the circuit, and consequently lessen the current flow.

We have seen before that the current equals the E. M. F. divided by the resistance, and in order to obtain th necessary current flow to operate the bell, we may eith clean the contact points to lessen the resistance, or increa *the E. M. F.* by adding another cell in series with the fir

The latter expedient is by far the better, because it gives us a little surplus of power which is very useful to overcome variations in adjustment of the contact spring, loose contacts, dirt, etc. We should avoid using too many cells as well as not enough. If too many cells are used, there

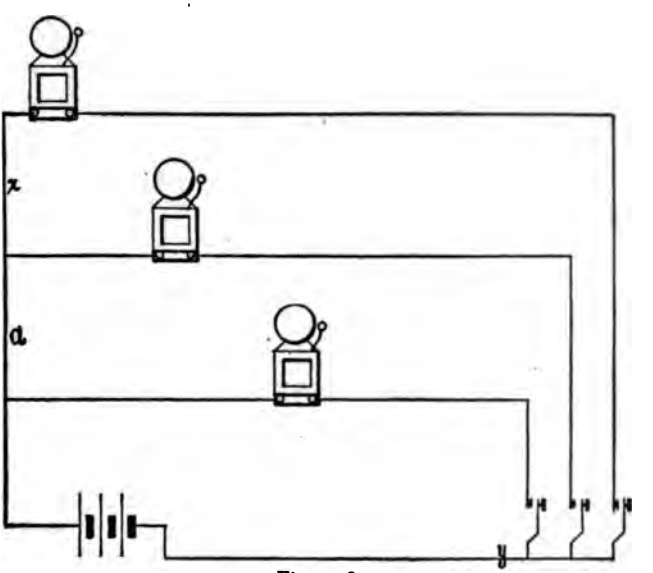


Figure 6

will be much unnecessary damage done to contact points by the larger sparks.

If the circuit is very long, the great length of wire will also provide additional resistance. This can be overcome in two ways, by increasing the E. M. F. as above, or by using larger wires. We have already seen that the larger the wire, the less will *be its resistance*. It is common practice to use

No. 18 copper wire for all ordinary distances and for single bells. With large bell systems, it is customary to use No. 16 or 14 for the main wire, which leads to all of the bells and may be called upon to supply several bells at the same time. Figure 6 shows a diagram of such a system and in case the three push buttons are used at the same time, three times as much current will flow in the main or battery wire *a* as in either of the other wires.

We have seen before that currents of electricity divide among different circuits in the inverse ratio of their resistances. In other words, the circuit having the least resistance will carry the most current. If our bell system, Figure 6, be "grounded" at the two points x and y (i. e., bare wire in contact with metal parts of buildings which are connected together) the current instead of flowing through the longer circuit and the bell, will flow through the short circuit and leave it impossible to operate the bells. If the contacts, at x and y are poor, i. e., of high resistance, only a small part of the current will leak from one to the other. In such a case, the bells may work properly, but the battery will soon run down and there is a strong likelihood that one of the wires will be eaten away through electrolytic action. To prevent troubles of this kind, bell wires should be well insulated and kept away from pipes or metal parts of building. Damp places should also be avoided and special care is recommended for the battery wire *a*, Figure 6. For further information concerning diagrams, etc., of bell circuits the reader is referred to *Wiring Diagrams and Descriptions* by the authors of this work, Fred J. Drake & Co., Chicago.

Bell wires are usually run along base boards, over picture mouldings, etc., in some cases they are also fished as explained further on. Batteries should be located in cool, dry places, where they are not liable to freeze, and where they are readily accessible as they must be kept nearly full of water *and must* be recharged from time to time.

The Telephone.

The principle and action of the Bell telephone can be best explained by reference to Figure 7. In this figure, A represents the transmitter, and B, the receiver. The essential parts of the transmitter are: the diaphragm, *a;* an electric circuit, containing a battery, *b,* and consisting of the wires, *c, c^1* and partly wound upon an iron core, *d.*

This electric circuit, it will be seen from the figure, connects with one pole to the diaphragm, *a,* and with the other to a small metal plate, *e.* Between the diaphragm, *a* (which is a plate of very thin iron), and the plate, *e,* there are many small pieces of carbon which complete the circuit. When now a party speaks into the mouthpiece of the transmitter,

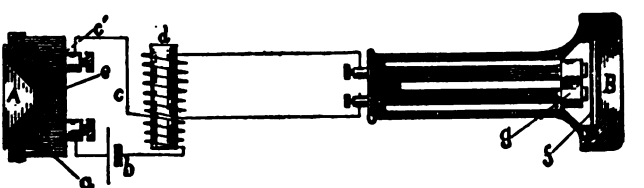


Figure 7

the sound waves cause the diaphragm, *a,* to vibrate; the rate of vibration and character of the vibrations being an exact duplication of the voice speaking into it. These vibrations cause the small pieces of carbon between the diaphragm and the back plate to be alternately compressed and allowed to expand. Now the resistance of these carbon pieces is decreased as they are tightly pressed together, and again increased when the pressure is released. Therefore the current of electricity flowing through them varies continuously while the diaphragm is in motion.

This varying current circulates around the lower part of the iron core, *d,* and the two windings upon it form an

ordinary induction coil. Every variation of current strength in the circuit of the transmitter is by means of it reproduced in the circuit of the receiver, *B*.

The essential parts of the telephone receiver are: The diaphragm *f*, very similar to that of the transmitter, the two magnets, *g*, and the electric circuit coming from the induction coil of the transmitter. The electric circuit, we have already seen, is traversed by electric currents exactly like those that flow in the circuit of the transmitter. These currents pass around electro-magnets, *g*, and attract the diaphragm, *f*, more or less strongly in proportion to the varying degrees of current strength.

In this manner the diaphragm, *f*, of the receiver is made to vibrate in exact unison with that of the transmitter, and thus to reproduce exactly the sounds given to the transmitter.

The transmitter is not absolutely necessary for the re-

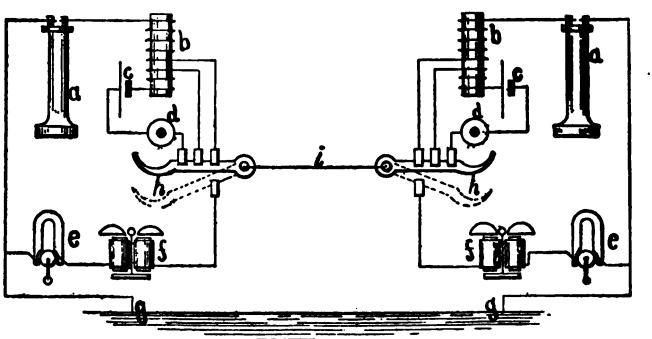


Figure 8

ceiver can be used as such, and in fact was so used at first. Lines of short distances can be operated without transmitters, but the speech will not be as plain.

Figure 8 is a diagram of the connections of two telephone instruments together with the necessary call bells. When the lines are not in use, the receivers, *a*, are hanging on the hooks, *h*, holding them down as shown by dotted lines. This leaves the circuit complete through the earth, *g*, magneto generator, *e*, bell *f*, line *i*, and duplicates of these parts at the right. When now the magneto generator is operated both bells will ring. When the receivers are removed, a spring forces the hook upwards making the connection shown in solid lines. This closes the battery circuit which must be open when the instrument is not in use or the battery will run down.

The talking circuit is now complete from earth, *g*, through the receiver, *a*, induction coil, *b*, line *i*, and duplicates of these parts at the right.

The Induction Coil.

Figure 9 is a diagramatic illustration of an induction coil as used mostly by medical men. Such an instrument

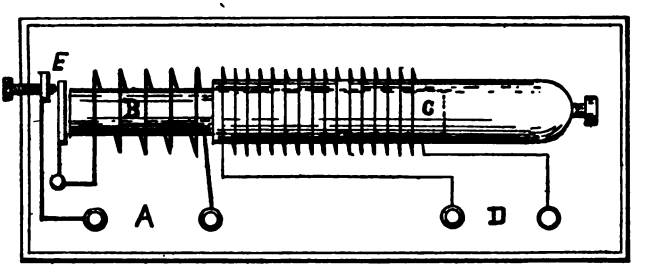


Figure 9

consists of an iron core, B, usually made up of a number of soft iron wires; and two electrical circuits insulated from each other, and terminating in the two pair of binding posts, A and D. Of these two circuits A consists of a short length

of comparatively heavy wire wound upon the iron core, and is known as the *primary* coil. D is a similar coil, but usually consisting of many more turns of wire, and the wire is also of much smaller gauge and is known as the *secondary* coil.

The operation is as follows: A battery is connected to the binding posts, A, and current begins to flow in the circuit. In this circuit is an interrupter or vibrator, E, constructed similarly to the one described in connection with the electric bell. As current flows through the primary coil, it magnetizes the core, B, and this attracts the armature, E, causing it to break the connection between itself and the adjusting screw. As this connection is broken, the current in A ceases to flow, the core is de-magnetized and the armature again connects with the adjusting screw. This action is repeated just as in the electric bell, and in consequence the core B, is rapidly magnetized and de-magnetized.

Every time the core, B, is magnetized a current of electricity, lasting, however, only an instant, is induced in the secondary coil, D. The magnetism in the core is caused by a current of electricity circulating around it, and currents of electricity are in turn produced by this magnetism in the other or secondary coil.

This method of producing electric currents is known as electro-magnetic induction, and currents so produced are said to be "induced" currents, hence the name induction coil. The currents so induced are alternating, that is, changing in direction. At the "making" of the primary circuit, the current in the secondary coil is in a direction which opposes the magnetization of the core by the primary current; at the time of "break" in the primary circuit, the induced current will be in the opposite direction.

The tube, C, is movable and may be slipped entirely in over the iron core, or withdrawn entirely. If it is in, the currents which were before being induced in the secondary wires are

now induced in the metal of the tube and consequently the effect on the secondaries is very much reduced.

The energy in the primary and secondary coils is always equal. If the two coils have the same number of turns, the currents and electro-motive forces are exactly alike. If the secondary coil has more turns of wire than the primary, the induced E. M. F. in it will be greater, but the current will be smaller and vice versa. The induction coil is very similar to the alternating current transformer, the main difference being that the transformer does not have an interrupter since the current supplied to it is itself constantly alternating.

Batteries.

Currents of electricity for commercial purposes are produced either by dynamo electric machines or by batteries.

A "battery" is the name given to a number of cells connected together so as to produce a current greater than one

Figure 10

Figure 11

cell alone could produce. Figure 10 shows one cell of a kind that is generally used only intermittently, as for instance with door-bells. When the bell is not ringing the battery is idle.

work, the cost of labor would not be appreciably affected thereby; similarily in connection with a pole line, the difference in total cost occasioned by the use of say No. 6 instead of No. 10 wire would be small.

Calculation of Wires.

In electrical calculations so far as they relate to wiring, the *circular mil* plays an important part, and it becomes necessary to thoroughly understand its meaning. The mil is the 1/1000 part of an inch, consequently one square inch contains 1,000x1,000 equals 1,000,000 *square mils.* If all electrical conductors were made in rectangular form, we should be able to get along nicely by the use of the square mil, but, since they are nearly all in circular form, the use of the square mil as a unit would necessitate otherwise unnecessary figures. The *circular mil* means the cross-section of a circle one mil in diameter, whereas the *square mil* means a square each side of which is equal to one mil in length. Square mils, can, therefore, be transformed into circular mils by dividing by .7854, and circular mils into square mils by multiplying by .7854, since it is well known that a circle which can be inscribed within a square bears to that square the ratio of .7854 to 1.

To illustrate: Using square mils if we wish to determine the cross-section of a wire having a diameter of 50 mils, we must first square the diameter and then multiply by .7854; 50 × 50 × .7854, or 1963.5, which is the cross section of the wire expressed in square mils. To express the cross-section in circular mils, we have but to square the diameter, or 50 × 50 = 2500 circular mils. The 2500 circular mils are exactly equal to the 1963.5 square mils. The adoption of the circular mil simply eliminates the figure .7854 from the calculations.

The resistance of a copper wire having a cross-section of

send current in one direction and six in the other, so that the result would be nothing. Should ten cells be properly connected to send current in one direction and two connected to oppose them, the net electro-motive force would be 10×1.4 minus 2×1.4, which is 11.2. The ten cells would force current through the other two in the opposite direction.

The electro-motive force of a cell is independent of its size, that is, a very small cell would set up just as high an electrical pressure as a very large one made of the same material. A large cell is, however, capable of delivering a much stronger current because its own resistance to the current flow is much less than that of a small cell. Large cells will, therefore, in most cases give very much better service than small ones. Especially in cases where considerable current is required as in electric gas-lighting and annunciator work, where it is always possible that two or three bells or fixtures may be called into action at the same time.

In setting up and maintaining sal-ammoniac batteries, the following general rules should be observed:

Use only as much sal-ammoniac as will readily be dissolved; if any settles at the bottom it shows that too much has been used. Keep your battery in a cool place, but do not allow it to freeze. See that the jars are always about ¾ full of water.

Keep the tops of glass jars covered with paraffin to prevent salts from creeping.

The battery should never be allowed to remain in action (i. e., send current) continuously, or it will run down. If it has been run down through a short circuit or other cause, it should be left in open circuit for several hours; it will then usually "pick up" again.

The so-called dry-batteries are made up of about the same material, but applied in form of a paste. They are

The above formula will answer for all 2-wire work, whether it be lights or power.

It is simply necessary to find the current required with whatever devices are to be used.

These calculations are not often made in actual practice. It is much easier to refer to tables such as II. III, IV, V, VI, given at the end of this volume, by which the proper size of wire can be determined at a glance almost.

In connection with 3-wire systems using two lamps in series, we need to calculate the two outside wires only, the neutral wire should then be taken of the same size. We must however assume double the voltage existing on either side of the neutral; that is to say, a 2-wire system using 110 volts would be figured at 110 volts, while a 3-wire system, using 110 volt lamps on each side of the neutral wire would be figured at 220 volts.

It must also be noted that with 3-wire systems the current required is only ½ of that required with 2-wire systems. Ordinarily we have two lamps in series and the same current passes through both. Applying this to our formula we see that with the 3-wire system the current I is only half as great as with 2-wire systems and (the percentage of loss in both cases being the same) V, which stands for the volts to be lost, becomes twice as great. Owing to these two factors, the wire for 3-wire systems need have only ¼ as many circular mils as that of a 2-wire system with the same percentage of loss. To this must be added the neutral wire so that the total cost of wire must be ⅜ of that for the 2-wire systems.

The amount of copper required in power transmission for a given percentage of loss varies as the square of the voltage employed. By doubling the voltage we can transmit power with the same loss four times as far; or, if we do not change *distance or wire,* we shall have only one-fourth of the loss

we had before. A practical idea of the laws governing the distribution of circuits and the losses in voltage and wire which are unavoidable may be gained from Figure 20.

Figure 20 shows 96 incandescent lights arranged on one floor and placed 10 feet apart each way. With all cutouts placed at A and circuits arranged as in No. 1, 2,080 feet of branch wiring for the eight circuits of 12 lights each, will be required. If the cutouts be placed in the center, B, the same length of wire will be necessary. We have in this case merely transferred the cross wires from one end of the hall to the center. If we arrange two sets of cutouts as at C and D and run circuits as 3 and 4 the total amount of wire necessary will be only 1,920 feet. By this arrangement we avoid the necessity of crossing the space indicated by dotted lines at the right, opposite B.

If we run the circuits on the plan of No. 2, the least amount of wire for the eight circuits will be 2,560 ft. Such wiring would require extra wires feeding the various groups. Should we run a set of mains along ACBD, and make 12 circuits of the installation by placing one cutout for each eight lights, the amount of wire required will be 1,680 feet. If we run a set of mains through B as shown by dotted lines using 12 lights per circuit, 1,760 feet of wire will be required. If we now double the number of lights in the same space or limit the number per circuit to six, we shall require 3,200 feet of wire to feed them all from A, but only 2,400 to feed them from B; to feed them all from the two centers C and D will also require 2,400 feet.

The most economical location of cutout centers will, with even distribution of light, and in regard to branch wiring only, be such that it is unnecessary to run circuits like No. 2; in other words, not more than the number of lights allowed on one circuit should lead away from it in one direction.

Suppose, for instance, the number of lights be increased

10 feet from this to the next, etc. The voltage at the cut-out A is 110 and at each lamp is given the actual voltage existing at that point with all lamps burning. The wire of the circuit is No. 14 and with 55 watt lamps, the loss to the last lamp over a run of 145 feet is a trifle over two and one-half per cent when all lamps are burning.

Circuit No. 2 is figured as of the same length as No. 1, and supplies the same number of lamps, but at a much greater loss, slightly over four per cent to the last lamp. Circuits 3 and 4 feeding from C contain equal lengths of wire, but there is quite a difference in loss; in 3 only .75 of one volt, while in 4 it is a little over two volts. From study of Figure 20 we may learn that the arrangement of circuit 1 is fairly satisfactory especially if the nature of the work done unde. it is such that only part of the lamps are used at the sam time. Circuit No. 2 is bad if all lights are used at once, an it should be wired with No. 10 or 12 wire. Whenever the location of lights is such as to allow a circuit like No. 3 to be run, the loss can be kept very low with a minimum of wire. In general the more cutout centers there are established in proportion to the number of lights, if mains are properly arranged, the less will be the loss in pressure and the more satisfactory the service.

NOTICE.—DO NOT FAIL TO SEE WHETHER ANY RULE OR ORDINANCE OF YOUR CITY CONFLICTS WITH THESE RULES.

CLASS A.

STATIONS AND DYNAMO ROOMS.

Includes Central Stations, Dynamo, Motor and Storage-Battery Rooms, Transformer Substations, Etc.

Generators.

a. Must be located in a dry place.

It is suggested that water proof covers be provided, which may be used in case of emergency.

Perfect insulation in electrical apparatus requires that the material used for insulation be kept dry. While in the construction of generators the greatest care is taken that all current carrying parts are well insulated, still, if moisture is allowed to settle on the insulation, trouble is almost sure to occur. For this reason a generator should never be installed where it will be exposed to steam or damp air or in any place where through accident water may be thrown against it. A location under steam or water pipes or close to an outside window should be avoided.

b. Must never be placed in a room where any hazardous process is carried on, nor in places where they would be exposed to inflammable gases or flyings of combustible materials.

In even the best constructed dynamos there is alyays more or less sparking at the *brushes* and small pieces of hot carbon

are sometimes thrown off. As a general rule in buildings where there is considerable dust, such as in wood-working plants, grain elevators and the like, the dynamo is located in the engine room, which is generally isolated from the dusty part of the building.

c. Must, when operating at a potential in excess of 550 volts, have their base frames permanently and effectively grounded.

Must, when operating at a potential of 550 volts or less, be thoroughly insulated from the ground wherever feasible. Wooden base frames used for this purpose, and wooden floors which are depended upon for insulation where, for any reason, it is necessary to omit the base frames, must be kept filled to prevent absorption of moisture and must be kept clean and dry.

Where frame insulation is impracticable, the Inspection Department having jurisdiction may, in writing, permit its omission, in which case the frame must be permanently and effectively grounded.

If desired, high potential machines may be surrounded by an insulated platform, made of wood, mounted on insulating supports, and so arranged that a man must always stand upon it in order to touch any part of the machine.

Under ordinary circumstances it is better to insulate the base frames of generators. Excessive voltages are often produced in the windings, as for instance, where the field circuits are opened, and unusual electrical strains result. A generator with an insulated base frame is, therefore, less liable to trouble from grounds than one in which the base frame is in electrical connection with the ground.

Where generators operate at high voltages, however, the question of life hazard must be considered. If the base frame is insulated from the ground there is always the possibility that a person touching it may receive a severe shock and for this reason it is deemed advisable to ground all generator frames where the voltage generated is over 550 volts.

The smaller generators are usually insulated on wooden base frames. A base frame suitable for this work is shown in Figure 21. Almost any kind of wood, well varnished, is very good for this purpose. The base frame is screwed to the floor or foundation and the slide rail (which is used where the dynamo is belted to the engine to allow the tightening and slackening of the belt) is independently attached to it, that is, the same bolt must not be used to hold the slide rail to the

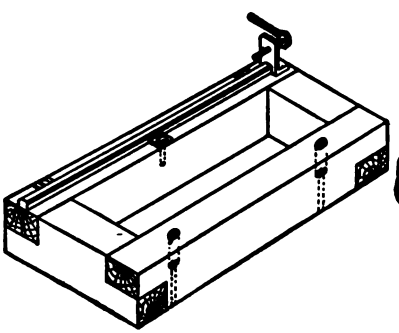


Figure 21.

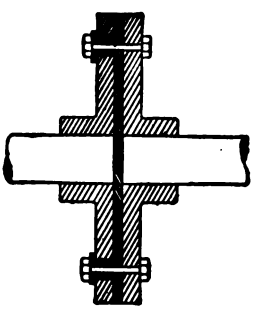


Figure 22.

base frame and the base frame to the floor, as this would be liable to ground the frame. The direct connected machines (dynamo and engine on same bed plate) are often insulated by the use of mica washers and bushings surrounding the bolts which fasten the dynamo to the bed plate and by using an insulated flange coupling between the shaft of the dynamo and that of the engine. Figure 22 shows a section of a flange coupling insulated in this way, the heavily shaded parts representing the insulating material.

The larger machines, which on account of their weight

cannot be insulated, must be permanently and effectually grounded. Where the engine and dynamo are direct connected a very good ground is obtained through the engine connections. Where belts are used a good ground can be obtained by fastening a copper wire under one of the bolts on the dynamo and connecting the other end of the wire to available water pipes.

In the case of high tension machines, especially series arc, the machine should always be surrounded by an insulated platform so arranged that a man must stand on it in order to

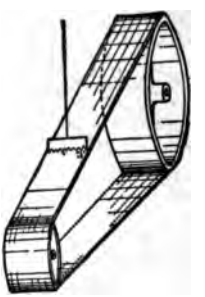


Figure 23.

touch any part of the machine, either live parts or frame, and in handling such a machine only one hand at a time should be used. A hardwood platform mounted on insulators will serve very well for this purpose or suitable platforms may be obtained from dealers in electrical supplies.

Figure 23 shows a metallic comb such as is occasionally used to overcome the static electricity due to the friction of the belt. A strip of metal, one end of which is cut with a number of projecting points, is suspended crosswise a short

distance above the belt. A wire connects this plate to any suitable ground.

A resistance for grounding the generator frame in accordance with this rule is constructed of ground glass equipped with two metal terminals separated a short distance and connected by means of a lead pencil mark. One terminal is connected to the frame of the machine and the other to the ground.

d. Constant potential generators, except alternating current machines and their exciters, must be protected from excessive current by safety fuses or equivalent devices of *approved* design.

For two-wire, direct-current generators, single pole protection will be considered as satisfying the above rule, provided the safety device is located in the lead not connected to the series winding. When supplying three-wire systems, the generators must be so arranged that these protective devices will come in the outside leads.

For three-wire, direct-current generators, a safety device must be placed in each armature, direct-current lead, or a double pole, double trip circuit breaker in each outside generator lead and corresponding equalizer connection.

Constant potential generators are designed to carry a certain amount of current without seriously overheating. If any considerable overload is put on a machine of this type a dangerous rise in the temperature of the generator and the wires connected to it will occur and a fire may result. To protect the apparatus some safety device must be installed in the main circuit which will cut off the current when it exceeds its normal maximum value. The safety fuse is commonly used for this purpose, but circuit breakers of approved design meet the requirements of the rule and may be used in place of the fuses.

Alternating current generators are usally constructed in large units. If a safety device installed in the main circuit of one of these large machines should operate and open the circuit, the generating apparatus, dynamo and engine would mo-

mentarily be left in a dangerous condition owing to of the load being suddenly removed from the gener

The sudden disrupting of the circuit of an alterna rent generator gives rise to a momentary, excessive in the E. M. F., and as this is usually already very h is great tendency to pierce the insulation of the winding.

In view of these facts, and for the further reaso short circuit the impedance of an alternating current consisting of many coils in series is generally of

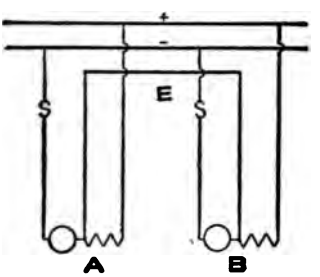


Figure 24.

amount as to limit the resultant current, alternatin generators are excepted from the general rule requ tection by safety devices. While the rule does nc protective devices in any alternating current gener it is the general practice, and it is advisable, t fuses or circuit breakers on the smaller size generato are used in isolated plants for instance.

Fuses are sometimes mounted on the generator the general practice at the present time is to mount on the switchboard. For two-wire, direct current g

e fuse will suffice, provided this fuse is located in the lead ıich is not connected to the series winding. The diagram gure 24 shows the proper location of the fuses. An inspec- n of this diagram will also show the reason for this re- irement. Two compound wound generators are shown con- cted in parallel. To avoid confusion the shunt field and itch connections are not shown. When the generators are erating together current from the brush on the right-hand e of machine A has two paths by means of which it can to the positive bus bar. One of these paths is through its n series field and the other through the equalizer connection

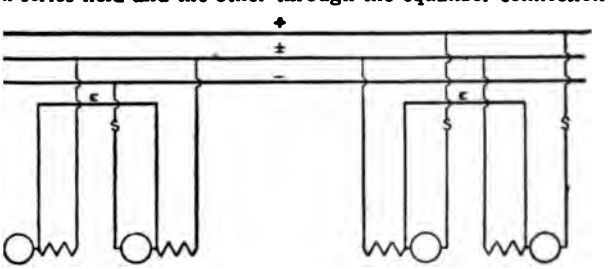


Figure 25.

series field of generator B. The current in the lead con- ted to the series field may not be of as great strength as generated in the armature; or, due to the fact that it r be receiving additional current from the other machine ıugh the equalizer connection, it may be of greater strength ı that generated in the armature. A fuse placed in this l could not, therefore, provide proper protection for the ıature.

Where a shunt wound generator is used the fuse may be ed in either lead. The same is true in the case of a single, ıpound wound generator, for no equalizer connection is

used in this case, and the current in both leads is always the same.

Where generators are feeding a three-wire system the fuses should be placed in those leads which feed into the positive and negative mains, Figure 25. They should not be placed in the equalizer lead or in the lead connected to the series field for the reasons already given. It will be noticed that the two generators shown at the right of the diagram are connected in a reverse manner from those at the left. An examination of the diagram, Figure 26, will show the reason for

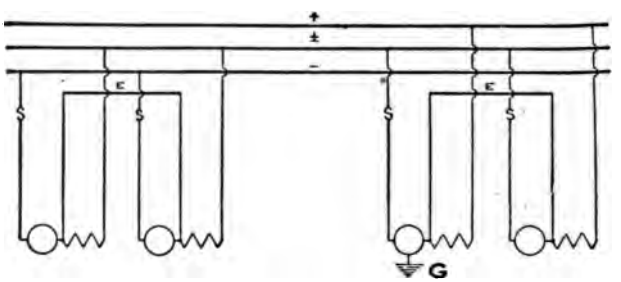


Figure 26.

this. In this case the placing of the fuse in the lead not affected by the equalizer current brings it in the lead connected to the neutral bus. If, with the fuse located in this line, the generator winding should become grounded a short circuit would result, as the neutral wire is always grounded, current flowing from the positive bus bar through the positive lead and the wires on the generator to the ground. The generator would have absolutely no protection in a case of this kind and a fire would be sure to result. If the fuses were placed in the outside leads the circuits would be immediately opened and current shut off from the machine.

Figures 27, 28 and 29 show the proper location of fuses in three-wire, direct current generator installations. In Figure 27 is shown the wiring connection of a three-wire direct current generator. The armature of this generator contains two separate armature windings, each winding being provided with its own commutator, located on each side of the armature. Two separate series field windings are provided, each

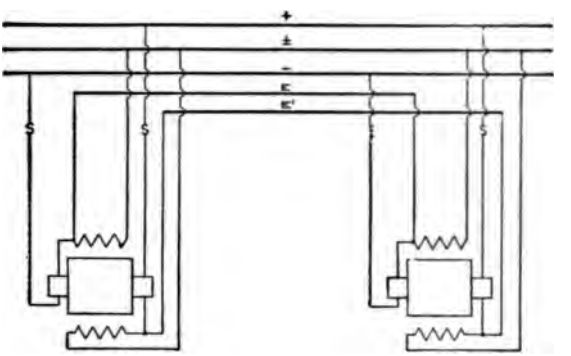


Figure 27.

field winding being connected in series with an armature winding. The shunt field connections are not shown.

To comply with the requirements each generator should be connected to the bus bars and fuses installed as shown. The simplified diagram, Figure 30, shows the reason for this arrangement. Referring to the connections shown it will be seen that the fuses protect each armature winding both from overload or from possible shorts caused by the grounding of the armature windings. A wrong arrangement of the fuses, and one that should be avoided, is shown in the diagram, Figure 31. In this case fuses are installed in the lead from

the series winding. The first objection to this arrangement is the one which has already been explained, *i. e.*, the current from the armature having two paths open to it, one through the series field and one through the equalizer, the armature could generate an excessive current without the fuse, which may be carrying only a part of the current, blowing. If for any reason one of the fuses shown did blow serious conditions might result owing to the fact that the arma-

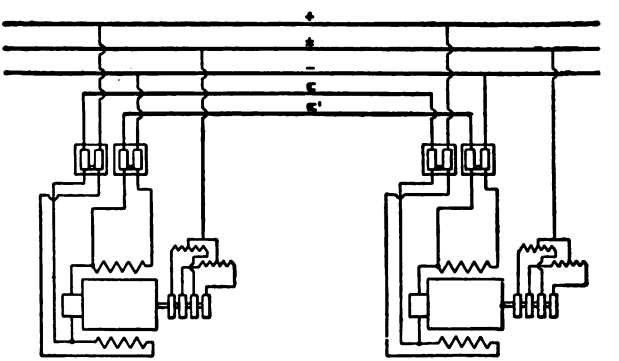


Figure 28.

ture of that machine is still connected to the armatures of all the remaining machines through the equalizer bus. A double-pole circuit breaker so arranged as to open both the series field lead and the equalizer lead would remove this objection, but, as the circuit breaker would be actuated by the current in the series field lead the objections before stated still exist. Locating the fuse in the armature lead connected to the neutral bus would leave the generator unprotected in case of grounds.

Figure 28 shows the connections of the Westinghouse direct

current, three-wire generator. In this generator direct current at the potential of the outside mains, usually 220 volts, is taken off the commutator side while the neutral connection is made through auto transformers to slip rings on the opposite side of the armature shaft. Two separate series field windings are connected in series with each direct current armature lead. In order to place a fuse in each direct current armature lead, fuses would have to be mounted on the generator itself or the

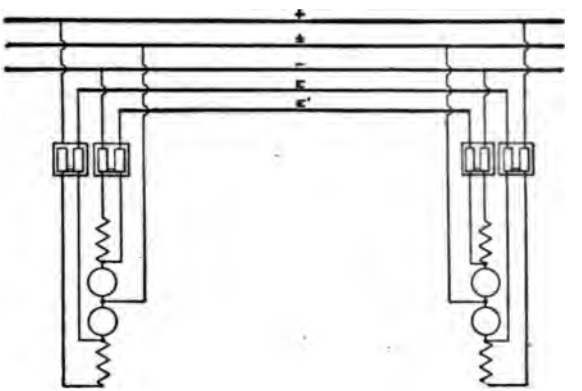


Figure 29.

leads would have to be carried from the armature brushes to the switchboard and back to the series field. The usual protection provided with this generator consists of double-pole, double-trip circuit breakers connected in the leads from the series fields and corresponding equalizer connection, this circuit breaker being actuated by the current in the lead from the series field and arranged to open both series field and equalizer leads. As this generator is designed to withstand only a 25 per cent overload the circuit breakers should be

interconnected so that in case one generator lead opens it automatically opens the remaining lead.

Figure 29 shows the wiring connections of a compensator set. This set consists of two machines, the armature shafts of which are rigidly connected together. Each machine acts as a motor or generator, depending on the condition of unbalance; and they are used only to balance the system, other generators supplying current to the outside mains.

This class of apparatus is protected in the same manner as in the case just described. A double-pole, double-trip circuit breaker should be installed in each outside lead and cor-

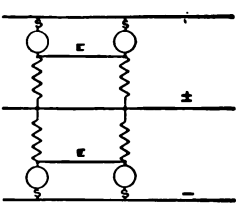


Figure 30.

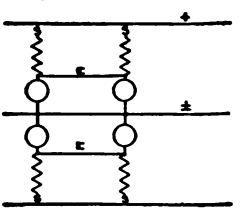


Figure 31.

responding equalizer lead. It might be well to state that with apparatus designed on the principle just described various details of construction of the machines, as built by the different manufacturers, require a more complicated system of protection so that the above rule is not always exactly complied with.

Circuit breakers, when used for protection in dynamo leads, are generally mounted on the switchboard and connected in the circuit ahead of the main switch. The circuit breaker as at present constructed is, in nearly all cases, a much more efficient and reliable device than the fuse, and its use is to be recommended. The fusing point of an ordinary

fuse depends on the temperature of the fuse metal. When fuses are used in an engine room where the temperature is often very high the fuse may blow when it is carrying a current very much less than its rated capacity, and this will generally result in a larger fuse being installed. The circuit breaker is not affected by this increase in temperature. When a fuse blows from overload it generally occurs at a time when all the appartus is in use and serious delays are apt to result before the fuse can be replaced. This objection does not exist where the circuit breaker is used.

As to the relative currents at which the fuse and circuit breaker should be set to operate, authorities differ. Some advise that both be set to operate at the same current strength so that the fuse, which takes a longer time to operate, will blow only in case the circuit breaker fails. Another recommends that the fuses be of such capacity as to carry any load which will be required of them and to set the circuit breaker a little higher than the fuses so that the fuses will operate on overload and the circuit breaker on short circuit. The practice of setting the fuses at about 25 per cent above the circuit breaker seems to be preferred, for it frequently happens, when both are set to operate at the same current strength, the fuse alone will 'blow," due to the excessive heat produced in the fuse at full load.

There is a tendency in the design of some of the newer generators to do away with binding posts, leads properly bushed through the generator frame and arranged for direct connection to leads from switchboard being provided instead. As this does away with exposed, live parts it is to be recommended. Where there are exposed live parts on the generator or its connections they should be protected from accidental contact, except where they are at the same potential as the ground, as in the case of the neutrals on the direct current three-wire systems and the ground return on trolley systems.

Cases are sometimes found where the cessation of current due to the blowing of a fuse could cause more damage than would result from an overload, as, for instance, where the dynamo operates some safety device. In cases of this kind the Inspection Department having jurisdiction may modify the requirements.

e. Must each be provided with a name-plate, giving the maker's name, the capacity in volts and amperes, and the normal speed in revolutions per minute.

f. Terminal blocks when used on generators must be made of *approved* non-combustible, non-absorptive insulating material, such as slate, marble or porcelain.

g. The use of soft rubber bushings to protect the lead wires coming through the frames of generators is permitted, except when installed where oils, grease, oily vapors or other substances known to have rapid, deleterious effect on rubber, are present in such quantities and in such proximity to motor or dynamo as may cause such bushings to be liable to rapid destruction. In such cases hardwood properly filled, or preferably porcelain or micanite bushings must be used.

2. Conductors.

(For construction rules see Nos. 49 to 57.)

From generators to switchboards, rheostats or other instruments, and thence to outside lines:—

a. Must be in plain sight or readily accessible.

Wires from generator to switchboard may, however, be placed in a run-way in the brick or cement pier on which the generator stands. When protection against moisture is necessary, lead covered cable or iron conduit must be used.

b. Must have an *approved* insulating covering as called for by rules in Class "C" for similar work except that in central stations, on exposed circuits, the wire which is used must have a heavy braided, non-combustible outer covering.

Bus-bars may be made of bare metal.

Where a number of wires are brought close together, as is generally the case in dynamo rooms, especially about the

witchboard, they must be surrounded with a tight, non-combustible outer cover.

Flame proofing must be stripped back on all cables a sufficient amount to give the necessary insulation distances for he voltage of the circuit on which the cable is used.

c. Must, when not in a conduit, be kept so rigidly in lace that they cannot come in contact.

d. Must in all other respects be installed with the same precautions as required by rules in Class "C" for wires carrying a current of the same volume and potential.

e. In wiring switchboards, the ground detector voltmeter, pilot lights and potential transformers must be connected to a circuit of not less than No. 14 B. & S. gage wire that is protected by an *approved* fuse, this circuit is not to carry over 660 watts.

For the protection of instruments and pilot lights on switchboards, *approved* N. E. Code Standard Enclosed Fuses are preferred, but *approved* enclosed fuses of other designs of *not over two (2) amperes capacity,* may be used.

A number of different methods are used for running wires in dynamo rooms. Where the dynamo is located in a room with a low ceiling, or where it is not desirable to run the wires open, metal conduits may be imbedded in the floor and the wires run in them. If the engine room is located in the basement or in any place where water or moisture is liable to gather on the wires, lead covered wires must be used or the wires must be run in iron conduit. It is permissible to install an ordinary braided rubber covered wire or cable without a lead covering in iron conduit, but in this case the greatest care should be taken that all joints in the conduit system are well leaded and well made so that the conduit system when installed will be water tight. In most installations the generator leads are not protected by fuses and a short circuit in them is very liable to result in a fire. The reliability of the whole plant is also dependent on the generator leads so that it is generally advisable, where moisture is present, to use lead covered wires or cables for generator leads. At outlets the conduits should

descent lamps are often used for this purpose and must be installed as in 4, Class A.

A speed controller differs from a starting box mainly in the size of wire used as resistance. The resistance coils of a starting box are wound with comparatively small-wire and connected in circuit for a short time only, generally from ten

Figure 46.

to twenty seconds, while in a speed controller the wire must be of sufficient size to carry the current as long as the motor is running. Another difference between the starting box and speed controller is the automatic coil (Fig. 43) M, which in the speed controller is arranged to hold the arm A in any position in which it may be placed. This is accomplished in some types of speed controllers by a lever attached to an

armature, which is attracted by the magnet M, the other end of the lever fitting into a series of indentations on lower part of movable arm.

While the underwriters' rules do not require a speed controller to be automatic, still it is good practice to make them so, as the same principles apply to the starting of a motor with a speed controller as with a starting box.

Figure 46 shows a circuit breaker which is operative during the starting of the motor, and can be used to take the place of the switch required. Circuit breakers should be frequently operated to assure that they are in working condition. This is especially necessary in wet or damp places where the mechanism is likely to become corroded and under such conditions it is sometimes advisable to use the circuit breaker for the usual operation of the apparatus in place of the switch. Overload devices on starting rheostats are also subject to corrosion in damp places and they should be frequently operated.

As the arm of a starting box or speed controller is moved from one contact to another, more or less sparking results, and, as has already been stated, considerable heat is developed in the coils. A rheostat should never be located in a room where either inflammable gases or dust exist. If a starting box is to be located in a room where considerable dirt is apt to gather, or if the room is unusually damp, the starting box should be mounted in a dust-tight fireproof box, which should be kept closed at all times, except when starting the motor. If the enclosing box is rather large, sufficient ventilation of the coils will be obtained while the motor is being started and the door open. A speed controller should never be mounted in an enclosure unless the same is arranged to give a thorough ventilation to the outside air, as heat is constantly being generated in the coils of the rheostat, and this heat must be dissipated. A speed controller should never be located

where dust or lint is apt to gather on it. If it is necessary to use one on a motor located in such a place, it should be mounted outside the room.

In metal working establishments or in any place where there is a liability of the contacts on the switches or the start-

Figure 47.

ing boxes being short-circuited, they should be enclosed or suitably protected.

Rheostats used in wet or damp places are more or less liable to corrosion of both the resistance elements and the sliding contact surfaces. A rheostat which has proven itself especially applicable in such places is shown in Figure 47. This rheostat is manufactured by the Allen-Bradley Co. and consists of a number of prepared graphite discs piled in a column and

frame so constructed as to support and substantially brace the slab. The metal frame should preferably, for low potential work, be insulated from the gound by mounting on wood or marble blocks; this, however, not being demanded by the Underwriters' rules.

The switchboards should be so arranged that all switches and other operating devices are in easy reach and the rear of the board should be free from unnecessary crossing of bus bars and other conductors. In designing a switchboard special attention should be paid to the manner in which the conductors are brought to the board and the bus bar work should be so laid out as to require the minimum amount of exposed rubber covered conductors.

It is well to keep all lights used for decorative or illuminating purposes entirely off the board as these complicate the wiring. Plenty of light should be provided both at front and rear of the board but these should be supplied by separate wiring.

Wires, or wires and bus bars, of opposite polarity should in no case come in contact and where liable to come in contact should be rigidly supported. All parts of the board should be easily accessible for inspection and repairs. A separation should be maintained between bus bars and conductors and any grounded metal part of the board. This separation should be as great as possible and in no case less than one-half inch.

Bus bars should be of ample carrying capacity. While the Code does not specify any particular carrying capacity for bus bars, this being considered more of an engineering feature as these bars are not surrounded by the usual combustible insulating material, still they should be of ample size. A bus bar that heats is liable to communicate heat to the fuses and cause them to blow below their designed capacity. Sizes and carrying capacities of bus bars commonly used are as follows:

work where more or less heat is developed. The more common uses of resistance boxes are given below and in each of these cases the device must be installed in accordance with the foregoing rules: starting boxes for motors, speed controllers for motors including elevator starters and the like, field rheostats for both motors and dynamos, resistances used in series with arc and mercury vapor lamps and theater dimmers.

On central stations where current is furnished over a large area there is on some of the circuits, especially the long ones, a considerable "drop," or loss of potential. In order to keep the voltage at the point of supply on these circuits at the proper value, the voltage at the station must be raised. This in turn causes the voltage on those circuits near the dynamo to become excessive. Equalizers, which are large resistance boxes generally constructed of iron wire or strips and capable of carrying a heavy current, are connected in the circuits and adjusted at such resistances as to make the voltage at the various points of supply uniform. They are generally too heavy to mount on the board, but should be raised on non-combustible, non-absorptive insulating supports and should be separated from all combustible material.

Starting boxes and speed controllers are resistance boxes connected in a motor circuit and so arranged that the amount of resistance can be varied. The resistance coils are mounted in an iron case with a slate or marble front on which are placed the terminals. Dynamo field rheostats are generally mounted on the back of the marble switchboard, a small hand wheel being provided so that the rheostat can be operated from the front of the board. If the switch board is of wood in skeleton form, or if the rheostat is placed on a wall or other support of combustible material, it should be mounted on a solid piece of slate or marble. Separate screws should be used for attaching the rheostat to the slate or marble and the slate or marble to the wall for, if the same screws were used for

this purpose they would be liable to ground the frame of the rheostat or might conduct heat to the material to which the rheostat is fastened. The method of fastening is shown in Figure 34 and this applies also to other forms of rheostats.

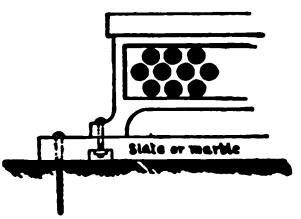


Figure 34

b. Where protective resistances are necessary in connection with automatic rheostats, incandescent lamps may be used, provided that they do not carry or control the main current nor constitute the regulating resistance of the device.

When so used, lamps must be mounted in porcelain receptacles upon non-combustible supports, and must be so arranged that they cannot have impressed upon them a voltage greater than that for which they are rated. They must in all cases be provided with a name-plate, which shall be permanently attached beside the porcelain receptacle or receptacles and stamped with the candle-power and voltage of the lamp or lamps to be used in each receptacle.

Automatic rheostats are arranged to control a motor automatically, usually from some point remote from the apparatus itself, this action being generally obtained by the use of solenoids.

The simplified diagram Figure 35 will show the manner in which this device operates. When the switch A is closed the solenoid B immediately draws up the core, at the lower end of which is attached a contact piece. The main circuit is then closed through the motor and resistance, this resistance being

b. Must be located in readily accessible places away from combustible materials, and as near as practicable to the point where the wires enter the buildings.

In all cases, kinks, coils and sharp bends in the wires between the arresters and the outdoor lines must be avoided as far as possible.

c. Must be connected with a thoroughly good and permanent ground connection by metallic strips or wires having a conductivity not less than that of a No. 6 B. & S. gage copper wire, which must be run as nearly in a straight line as possible from the arresters to the ground connection.

Ground wires for lightning arresters must not be attached to gas pipes within the buildings nor be run inside of iron pipes.

d. All choke coils or other attachments, inherent to the lightning protection equipment, shall have an insulation from the ground or other conductors equal at least to the insulation demanded at other points of the circuit in the station.

A lightning discharge is simply a discharge of electricity at very high potential. While the insulation of the ordinary wire serves very well for the voltages for which it is designed it offers very little resistance to a current of such high potential, and, providing the discharge can reach the ground by jumping through the insulation, it will generally take that course unless some easier path is offered to it. A lightning arrester in its simplest form consists of two metal plates separated by a small air space as shown in Figure 36. One of the plates is connected to the line and the other to the ground, a set being provided for each line wire to be protected.

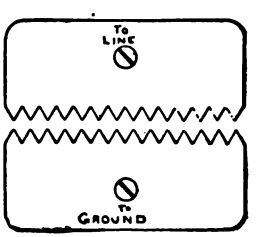


Figure 36.

The air space between the metal plates offers a much lower resistance to the passage of this high potential than do the

agnets of a dynamo, for instance, or highly insulated parts
the line. The current, therefore, jumps the air space and
isses to ground. When the current jumps this air space it
oduces an arc similar to that of an arc lamp, and after the
ghtning discharge is over the dynamo current is very likely
maintain this arc and thus cause a short circuit from one
ghtning arrester through the ground to the other. Different
ethods of preventing this by interrupting the arc have been
vised.

Figure 37 shows the T. H. lightning arrester, in which
e arc is extinguished by a magnetic field set up by the elec-
o-magnet. In the non-arcing lightning arrester (Figure 38)
e discharge takes place across the air gaps between the
linders.

A choke coil is simply a coil of wire, the size of wire and
e number of turns depending upon the normal current and
oltage of the system on which it is used. On 500 volt street
ilway circuits the choke coil sometimes consists of a spiral
five or six turns of heavy copper rod, while on high po-
ntial, alternating current circuits a greater number of turns
id smaller wire is used. As every coil of wire has a certain
nount of inductance, or, in other words, tends to hold back
y change in the E. M. F., the placing of a coil in the cir-
uit between the lightning arrester and the apparatus on which
e current is used affords a protection to the apparatus and
rces the lightning discharge to pass to the ground through
e lightning arrester.

As the lightning arrester and choke coil are subjected to
tremely high potentials they should be carefully insulated
id properly located.

Care and Attendance.

a. A competent man must be kept on duty where gen-
ators are operating.

b. Oily waste must be kept in *approved* waste cans and removed daily.

7. Testing of Insulation Resistance.

a. All circuits except such as are permanently grounded in accordance with No. 15 must be provided with reliable ground detectors. Detectors which indicate continuously and give an instant and permanent indication of a ground are preferable. Ground wires from detectors must not be attached to gas pipes within the building.

b. Where continuously indicating detectors are not feasible the circuits should be tested at least once per day, and preferably oftener.

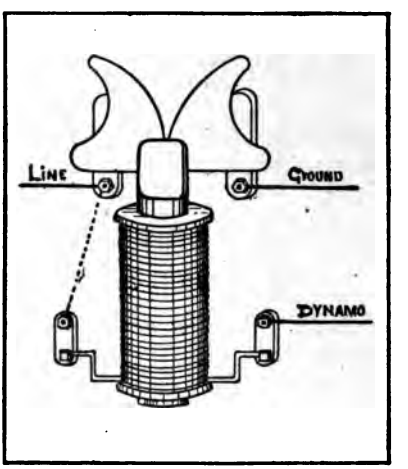


Figure 37.

The exceptions to this rule are 3-wire direct current systems where the neutral is grounded and 2 and 3 wire alternating current secondaries where the neutral or one side is grounded.

n every installation of electric wiring there is a certain
k" of current. This leak is partly between the wires and
ground and between the wires themselves. The amount of
varies, but is always dependent on the insulation resist-
. Where a small amount of wire is well installed the leak
ıld be very small, but in the case of large installations

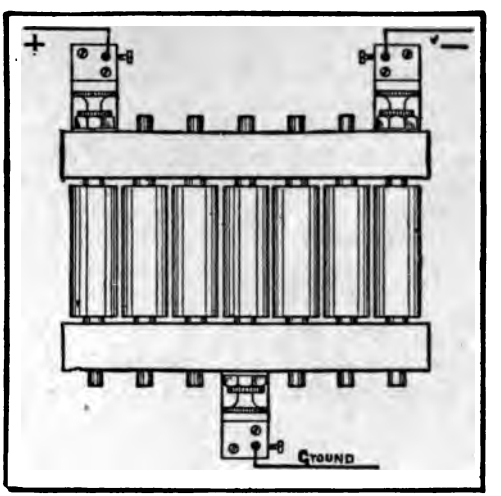


Figure 38.

where the wiring has been poorly done the flow of current
ground or between the wires of opposite polarity may be-
ıe quite large. Wires lying on pipes or on damp wood-
k, crossed wires or live parts of apparatus mounted on
)den blocks, all tend to cut down the insulation resistance
increase the leak. The effects of poor insulation are:

First, it represents a useless loss of current, and, second, and more important, it means a possible cause of fire.

The simplest way to determine the insulation resistance of a circuit is by means of a voltmeter. In Figure 39 if a voltmeter of known resistance is connected between one side of the circuit and the ground and there is a ground on the other side of the circuit, say at X, current will flow from the positive wire through the voltmeter, then through the ground at X to the negative side of the circuit. The voltmeter needle will indicate a certain reading which we will call V^1. If the voltmeter is now connected directly across the circuit we get the circuit voltage, which we will call V. The two readings, V^1, and V, are to each other as the resistance of the voltmeter is to the combined resistance of the voltmeter and the ground at X; or, calling the resistance of the voltmeter R and the resistance of the ground at X r, we get

$$\frac{V^1}{V} = \frac{R}{R+r}, \text{ or } r = R\frac{V - V^1}{V^1}$$

As an example: On a certain system the voltage across the mains is 110, while with the voltmeter connected as shown in

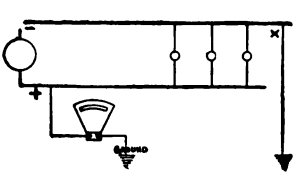


Figure 39.

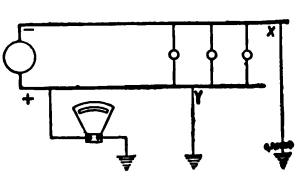


Figure 40.

Figure 39 we obtain a reading of 38. The resistance of the voltmeter is 10,500 ohms. Supplying the numbers in the for-

mula, $r = 10{,}500 \times \frac{110-30}{30} = 28{,}000$ ohms as the resistance to ground the negative side of the system. If the voltmeter is connected to ground from the other side, or — main, the resistance to ground of the + side can be obtained.

If both sides of the system are grounded as at x and y, Figure 40, the voltmeter will be robbed of part of the current which would pass through it if Y were not in parallel with it. It will therefore not indicate correctly under such circumstances. If Y for instance were a very good ground the voltmeter would give no indication whatever of the ground at x.

If, however, tests are frequently made and defects cleared up at once when noticed it will seldom happen that two grounds occur on the system at the same time. An engineer or dynamo tender will soon learn what the insulation resistance of the plant in his charge should be and be governed accordingly.

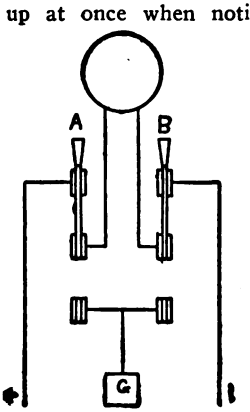


Figure 41.

A diagram of a direct current ground detector switch is shown in Figure 41. By throwing switch A down the — bus bar is connected to the ground through the voltmeter and by throwing switch B the + bar is connected to ground through the voltmeter. The ground wire should be run to a water or steam pipe (never to a gas pipe) or to some grounded part of the building. If no good ground is obtainable one may be made as described under 15 g.

8. Motors.

a. Must, when operating at a potential in excess of 550 volts, have no exposed live metal parts and have their base frames permanently and effectively grounded.

Motors operating at a potential of 550 volts or less must be thoroughly insulated from the ground wherever feasible. Wooden base frames used for this purpose, and wooden floors, which are depended upon for insulation where, for any reason, it is necessary to omit the base frames, must be kept filled to prevent absorption of moisture, and must be kept clean and dry. Where frame insulation is impracticable, the Inspection Department having jurisdiction may, in writing, permit its omission in which case the frame must be permanently and effectively grounded.

If desired, high-potential machines may be surrounded with an insulated platform made of wood, mounted on insulating supports, and so arranged that a man must stand upon it in order to touch any part of the machine.

Where motors with grounded frames are operated on systems where one side is either purposely or accidentally grounded there exists a certain difference of potential between the windings and the motor frame, this difference of potential depending on the part of the circuit considered. At some places in the winding it will be the full difference of potential at which the motor is operating and at other points practically nothing. Should the conductors accidentally come in contact or "ground" on the motor frame a short circuit would result, as the circuit would then be completed through the motor frame and ground. To obviate this the motor frame should be insulated from the ground. This may be done either by setting the motor on a wood floor or by the use of a base frame, as with generators. A base frame should always be used where possible, for when a motor is set directly on the floor it is often impossible to keep the space under it clean, and there is always a liability of the floor being damp or of nails in the floor passing through the woodwork into some grounded part of the building or metal piping. A properly

For conduit work, wires must be placed so as to conform to rules for unlined conduit except that conduit system must be waterproof.

c. Must be at least seven feet above the highest point of flat roofs, and at least one foot above the ridge of pitched roofs over which they pass or to which they are attached and roof structures must be substantially constructed.

For conduit work exposed to the weather all joints should be leaded. Marine type boxes should be used, or in lieu of these, special waterproof boxes. The marine type box is provided with a threaded inlet into which the pipe can be screwed and is also provided with a gasketed cover. Special boxes follow this same design and are arranged to be made absolutely watertight. The ordinary conduit construction with locknuts and bushings should never be used for outside work.

It is well to avoid fastening wires perpendicular above one another, as in winter icicles may form which extend from the top to the lower wire, and the moisture on these will often cause much trouble. The rule requires that wires be 7 feet above flat roofs, and roof structures must, therefore, be made high enough to allow for "sag." In moderately long runs 2 or 3 feet will be sufficient. For long runs, see following table, taken from construction rules of Commonwealth Edison Company of Chicago:

The tension on wires should be such that the sag of a span of 125 feet will not exceed the amounts shown.

Temperature, F..	10	20	30	40	50	60	70	80	90
Sag, inches	6	8	8	10	10	12	12	14	14

This table will also be useful to consult when running wires over housetops to which they are not attached, as it shows the variation in "sag" due to different temperatures. Wires should be so run that even at the highest temperature they will still clear the buildings. Allowance should also be made for the gradual elongation of the wire to its own weight, giv-

Varying speed motors are motors in which the speed varies automatically with the load, decreasing when the load increases, and vice versa. It does not mean motors in which the speed is varied by the use of different windings or grouping of windings, or motors in which the speed is varied by external means, and in which, after adjusting to a certain speed, the speed remains practically constant.

The insulation of the several conductors for high potential motors, where leaving the metal sheath at outlets, must be thoroughly protected from moisture and mechanical injury. This may be accomplished by means of a pot head or some equivalent method. The conduit must be substantially bonded to the metal casings of all fittings and apparatus connected to the inside high tension circuit.

Where outside wires direcly enter the motor room the Inspection Department having jurisdiction may permit the wires for high potential motors to be installed according to the general rules for high potential systems.

Good values to use for calculating the size of wire for branch conductors are given below. The question of loss of voltage is not taken into consideration here.

110 volts .....9.3 amperes per horsepower
220 volts .....4.6 amperes per horsepower
500 volts .....2 amperes per horsepower

For mains supplying many motors it is not necessary to provide the twenty-five per cent. overload capacity, because it is not likely that all motors will start at the same time. If, however, any one motor has more than half the capacity of the whole installation, it is advisable to provide the overload capacity. For instance, if two motors, each of 50 amperes capacity, are fed over a line of 100 amperes capacity, and one is started while the other is working at full load, they will overload that line twelve and one-half per cent.

For mains supplying many small motors the size should be chosen for the total load connected, using the following values:

110 volts .....7.5 amperes per horsepower
220 volts .....3.75 amperes per horsepower
500 volts .....1.65 amperes per horsepower

Where there are a number of 110-volt motors installed on the Edison 3-wire system, providing the load is evenly balanced between the two sides, the mains may be figured as though the motors were operating at 220 volts. The reason for this will be easily seen when it is remembered that two 110-volt motors operating in series on 220 volts (as they do on the Edison 3-wire system) take only one-half the current they would if operated on a straight 2-wire 110-volt system.

c. Each motor and resistance box must be protected by a cut-out and controlled by a switch (see No. 19 *a*), said switch plainly indicating whether "on" or "off" (except as provided for electric cranes, see No. 43 *c*). Small motors may be grouped under the protection of a single set of fuses, provided the rated capacity of the fuses does not exceed 6 amperes. With motors of one-fourth horse power or less, on circuits where the voltage does not exceed 300, single pole switches may be used as allowed in No. 24 *c*. The switch and rheostat must be located within sight of the motor, except in cases where special permission to locate them elsewhere is given, in writing, by the Inspection Department having jurisdiction.

Where the circuit-breaking device on the motor-starting rheostat disconnects all wires of the circuit, the switch called for in this section may be omitted.

Overload-release devices on motor-starting rheostats will not be considered to take the place of the cut-out required by this section if they are inoperative during the starting of the motor.

An automatic circuit-breaker disconnecting all wires of the circuit may, however, serve as both switch and cut-out.

Every motor and starting box must be protected by a cut-out and controlled by a switch except in the case of groups of motors used on electric cranes where only one main switch is required and switches need not be placed on the separate

motors. The switch and cutout must be so located that cu must first pass through them before passing through the s ing box or the motor. For the larger size motors a cu must be provided for each motor, but the smaller motors, s as those of nominal 1/6th and 1/8th horse-power, may grouped on one circuit provided the rated capacity of the fu protecting this circuit do not exceed 6 amperes.

Small motors of the horse-power mentioned vary great in the current required to operate them and the horse-pow ratings are generally of no value in determining the num ber to be allowed on a circuit. The particular conditions ex isting in each case must be taken into consideration and where a number of motors are to be switched on at one time the starting currents must be provided for. With alternating current motors of small horse-power ratings heavy starting currents are frequently required and motors of 1/8th horse-power rating will often blow six ampere fuses. Obviously motors of this kind must each be provided with separate circuits.

Every motor, whether large or small, must be controlled by a switch which will indicate whether the current is on or off. A motor may from overload or other causes fail to start and if a snap switch is used which does not indicate whether the current is on or off it would be easily possible to leave the motor with the current turned on.

As a general rule fused knife switches are used for the larger motors, while with the smaller motors cut-out blocks and indicating snap switches are often used. If the motor is of 1/4th horse-power or less, and operated on a circuit where the voltage does not exceed 300, a single-pole switch may be used. For all motors over 1/4th horse-power, and for all motors operated on voltages over 300, except in the case of street railway circuits, double-pole switches must be used. The reason for locating the switch and starting box within sight of the motor is that, should any trouble occur when the motor is

being started, such as short circuit or overload, it will be immediately noticed and the current shut off. It is also possible that where the motor and switch are not within sight of each other some person might be working on the motor at the time it was turned on. Figure 42 shows a complete direct current motor installation as usually arranged.

If the conditions are such that it is necessary to locate the motor out of sight of the switch and starting box, the motor

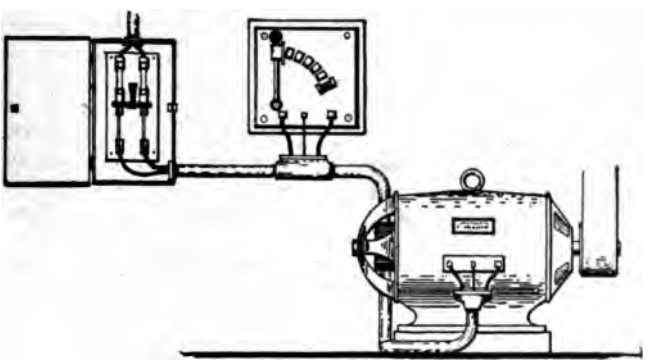


Figure 42.

should be located in a safe place away from combustible material. It may also be advisable to provide some means for determining at the point of control whether or not the motor is starting. A switch arranged at the motor to cut off the current while any one is working on it will also avoid possible accidents from that source. A special permit should be obtained from the inspection department having jurisdiction in order that the exact conditions may be noted.

d. Rheostats must be so installed as to comply with *all* the requirements of No. 4. Auto starters must comply with requirements of No. 4 *c*.

Auto starters, unless equipped with tight casings enclosing all current-carrying parts, in all wet, dusty or linty places, must be enclosed in dust-tight, fireproof cabinets. Where there is any liability of short circuits across their exposed live parts being caused by accidental contacts, a railing must be erected around them.

A starting box is a device for limiting the current strength during the starting of the motor by inserting a resistance in series with the armature. The ohmic resistance of the armature of a shunt or compound wound motor is ordinarily very small. When such a motor is at rest and the current thrown directly on, the full voltage is thrown across the small resistance of the armature. Consider for a moment the case of a 1 horsepower 110 volt motor having an armature resistance of say 2 ohms, and taking, when running normally, 8 amperes. Suppose the current were thrown on without the use of a starting box. According to Ohm's law the current through the armature would be $110/2=55$ amperes. The results, were 55 amperes sent through the armature, can easily be imagined. Now, suppose a resistance of 8 ohms were inserted in series with the armature when starting. In this case $110/10=11$ amperes only would have to pass through the armature, and this the armature can easily stand. As the motor begins to revolve a counter electro-motive force is generated which opposes the inrush of current. This counter electro-motive force increases until the motor reaches full speed and takes its normal current.

In the example given above at the first step of the starting box there will be a current of 11 amperes flowing through a resistance of 8 ohms and the power consumed will be equal to I^2R, or 968 watts, which are lost in heat produced in the resistance wire. As this amounts to more than one

›rsepower thrown off in heat the advisability of mount- g the rheostat away from combustible material and of prop- 'ly ventilating it can readily be seen.

Figure 43 shows an illustration of an *automatic* starting ›x, and a diagram of the connections to a motor circuit. It 'ill be seen that the resistance coils are in series with the rmature circuit. As the arm A is moved to the right, resist-

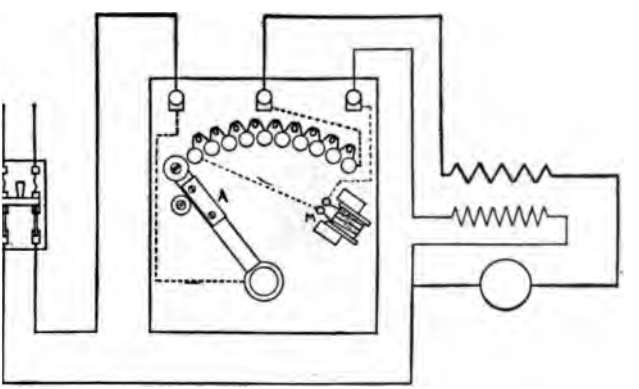


Figure 43.

nce is gradually cut out of the armature circuit until the rm reaches the last point, where it is automatically held in ›sition by means of the small magnet M, which is connected ı series with the field circuit. By tracing out the circuits it 'ill be found that the field connection is made on the first ›int of the rheostat, so that when the arm A is in the "off" ›sition there is no current passing through the field coils. t will also be noticed that the last contact upon which the rm rests when "off" is dead.

If the supply current for any reason fails, current will cease to flow around the coils of the magnet M and it will become demagnetized, thus allowing the arm A to fly back to the "off" position. This prevents the main current being momentarily shut off and then thrown on when all the resistance is out of the armature circuit. This device is known as "no-voltage" release.

Another device known as the "overload" release is shown in Figure 44, with a diagram of the connections. The winding of the magnet M^1 carries the main current. When the

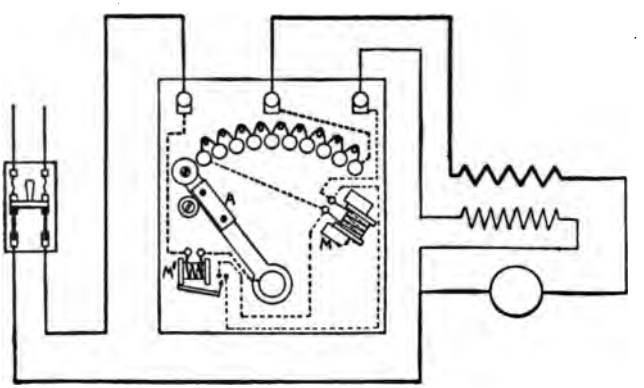


Figure 44.

current exceeds a certain amount (which can be regulated by an adjusting screw the armature below the magnet will be attracted, thus short circuiting the coil M and allowing the arm to fly back and shut off the current to the motor. This device cannot be considered to take the place of the regular cut-outs, as it is not operative during the starting of the

motor. It can only operate after the arm A is held in position by the magnet M.

Starting boxes are made in different designs to meet the requirements of the various classes of work on which they

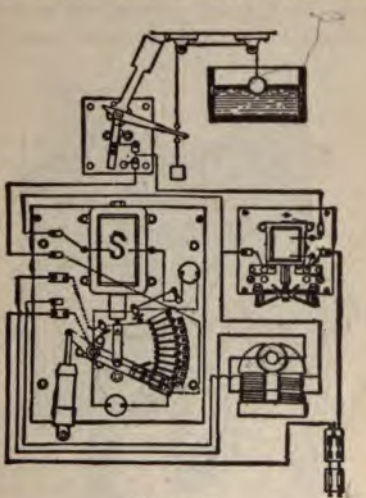


Figure 45.

are used. Figure 45 shows a large automatic starting box where the resistance is cut out by the action of the solenoid S, which draws up the movable arm. When solenoids are used for this purpose it is often advisable to arrange the connections so that when the movable arm has been raised to the highest and last point a resistance will be inserted in series with the solenoid to cut down the current and reduce the heating in the coil, as less current is required to hold the arm in place than to move it over the contacts. Incan-

wires can in a measure prevent such a wire coming in contact with the lower wire, but it is conceivable that the wire in question be broken off at such a distance from the pole that it will swing over and lodge on top of the lower wires. If the cross-over poles are to be set farther apart to lessen this danger, they must be increased two feet in height for every foot they are moved to one side.

Figure 58 is a suggestion towards making crosses on a joint pole. It is simply a trough-like screen built around

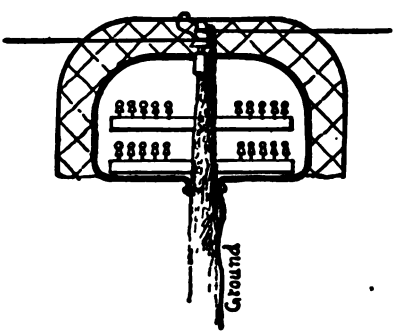


Figure 58.

the lower wires and set so that it must catch the upper wires when they break and confine them so that the wind cannot whip them out.

A cross-over made on a joint pole in some such manner as this is probably the most satisfactory. Wires are absolutely prevented from coming together, and such a pole being braced by the wires in two ways would seem to be quite safe. When wires cross at rather an acute angle the screen mentioned stretched from pole to pole under the upper wires is probably the best safeguard.

A joint pole may be erected at the crossing point, high-pressure wires being supported on this pole at least three feet above the other wires. Mechanical guards or supports must then be provided, so that in case of the breaking of any upper wire it will be impossible for it to come into contact with any of the lower wires.

Such liability of contact may be prevented by the use of suspension wires, similar to those employed for suspending aerial telephone cables, which will prevent the high-pressure wires from falling in case they break. The suspension wires should be supported on high potential insulators, should have ample mechanical strength, and should be carried over the high-pressure wires for one span on each side of the joint pole, or where suspension wires are not desired guard wires may be carried above and below the lower wires for one span on each side of the joint pole, and so spread that a falling high-pressure wire would be held out of contact with the lower wires.

Such guard wires should be supported on high-potential insulators or should be grounded. When grounded, they must be of such size, and so connected and earthed, that they can surely carry to ground any current which may be delivered by any of the high-pressure wires. Further, the construction must be such that the guard wires will not be destroyed by any arcing at the point of contact likely to occur under the conditions existing.

Whenever neither of the above methods is feasible a screen of wires should be interposed between the lines at the cross-over. This screen should be supported on high tension insulators or grounded and should be of such construction and strength as to prevent the upper wires from coming into contact with the lower ones.

If the screen is grounded each wire of the screen must be of such size and so connected and earthed that it can surely carry to ground any current which may be delivered by any of the high pressure wires. Further, the construction must be such that the wires of screen will not be destroyed by any arcing at the point of contact likely to occur under the conditions existing.

When it is necessary to carry such lines near buildings, must be at such height and distance from the building to interfere with firemen in event of fire; therefore, if 25 feet of a building, they must be carried at a height ss than that of the front cornice, and the height must

be greater than that of the cornice, as the wires come near to the building, in accordance with the following table:—

Distance of wire from building. Feet.	Elevation of wire above cornice of building. Feet.
25	0
20	2
15	4
10	6
5	8
2½	9

It is evident that where the roof of the building continues near in line with the walls, as in mansard roofs, the height and

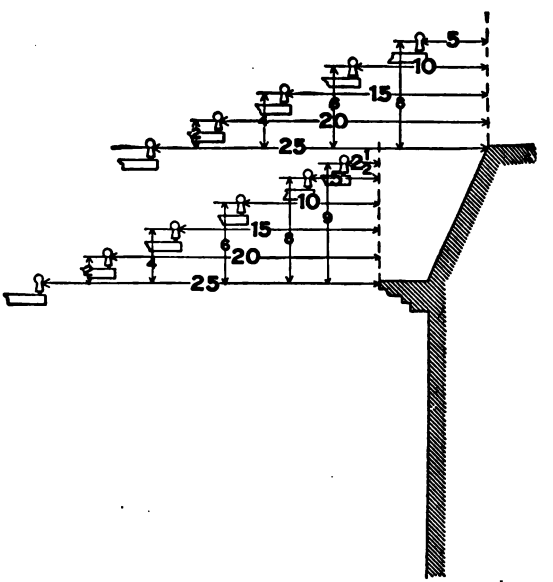


Figure 59.

tance of the line must be reckoned from some part of the roof instead of from the cornice.

A graphic illustration of the rule concerning the plac- ; of poles near buildings is given in Figure 59. The upp r ›up of figures and insulators shows the distance from the ilding and the corresponding height above high point of ›f required with mansard roofs. Distance being measured ›m the roof. The lower groups show measurements taken ›m cornice line as will be proper with ordinary flat roofed ildings.

Transformers.

ee also Nos. 11, 15, 36 and 45. For construction rules, see No. 81.)

Where transformers are to be connected to high-voltage circuits, is neecssary in many cases, for best protection to life and prop- y, that the secondary system be permanently grounded, and pro- ion should be made for it when the transformers are built.

a. Must not be placed inside of any building, excepting ıtral stations and sub-stations (except as provided in No.), unless by special permission of the Inspection Depart- ːnt having jurisdiction.

b. Must not be attached to the outside walls of buildings, less separated therefrom by substantial supports.

Must not be attached to frame buildings when any other ːation is practicable.

As a rule transformers are fastened to buildings on hori- ntal bars of wood. This method is as satisfactory as any if ɛ wood itself is securely enough fastened to the ›oden supports of the transformer should be fastened to the ıll either by suitable expansion bolts or better still by bolts ssing entirely through the wall. In fastening transformers poorly constructed walls where permission to go through ɛ wall cannot be obtained, some advantage can be gained supporting the transformer supports set vertically as shown Figure 60. It must be borne in mind that there is not only downward strain on the supports but also an outward

tipping strain. Almost any wall will stand the downward strain but in a loosely constructed wall there may not be a good hold for the bolts and a heavy transformer may tear them out as indicated. If the transformer is supported as shown the supports may be distributed over a much larger wall area and a much greater leverage obtained against tipping strain than would be possible with horizontally arranged timbers. It

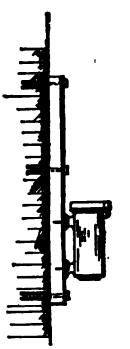


Figure 60.

is always better practice when possible to keep transformers off of buildings and mount them on poles.

The alternating current transformer consists of an iron core upon which wires of two distinct electrical circuits are wound. One of these is known as the *primary* circuit, and in it the high pressure currents coming direct from the dynamo circulate. The other is known as the *secondary* circuit, and in it the low pressure currents used inside of building circulate. These two circuits are wound generally one over the other, and are very close together. The pressure used in the

primary coil is from 1,000 to 5,000 volts, while in the secondary it is reduced usually to 110 or 220.

It quite frequently happens that the insulation between the two windings breaks down and thus the high pressure is accidentally brought into buildings. Under such circumstances should any one touch any live part of the installation while touching also grounded parts of the building death would very likely result. Also, should there be a weak spot in the insulation, it is quite likely the high pressure would pierce it at that point with a possible result of a fire. Many deaths and fires have been caused in this way. If such lines are connected to ground the chances for harm are very much lessened, for the current will never take the path of high resistance through a man's body while a direct path through a low resistance wire is open to it.

It must not be supposed that "grounding" one side of an electric light system is not often followed by serious consequences, for under such circumstances a ground coming on any other part of the system will cause a short circuit at once. The grounding in these cases is to be looked upon as the lesser of two evils rather than as an advantage.

Grounding the secondary tends to increase the danger from fire by increasing the electrical strain on the wires and fittings and, further, by increasing the tendency to short circuits. In an ungrounded system there is always the insulation of both sides of the system between conductors of opposite polarity as, for instance, in the case of the wires where current must pass through two insulations before a short circuit can occur, it is also necessary for both sides of the system to become grounded before a short circuit can occur. In the grounded system the insulation on the grounded wire is useless so far as short circuits through the ground are concerned as current must pass through one insulation only to produce a short.

On the other hand the danger to life is greatly decreased by the grounding of the secondary as has already been explained, and the danger from fire is somewhat decreased by making it impossible for the high tension current to enter the building. As secondary voltages for commercial use vary from 110 to 550 volts it is evident that some limit must be placed on the secondary voltage which it shall be permissible to ground. Obviously it would be inadvisable to ground a secondary having a potential of 550 volts to ground as the danger from fire and to life would be greatly increased. The proper limiting voltage for grounding has been a subject of much discussion. The solution of the question as it effects the fire hazard is determined by the number of fires occuring on systems with grounded secondaries from short circuits on the secondary and the number of fires occurring from crosses between the primary and secondaries. The proper voltage is, of course, that voltage which will give the minimum number of fires.

The limiting voltage from the life standpoint is likewise determined. It is a matter of record that numbers of fatal accidents have occurred from contact with both 110 and 220 volt circuits, while a contact with a secondary which has become crossed with the primary nearly always results fatally. The Underwriters have set the limiting voltage at 250. (See Rule 15 b.)

With alternating currents, the chances of possible damage from grounding are less than with direct currents, because each transformer with its small group of lamps is a system by itself and not affected by grounds on other transformers. Thus a 5,000 light alternating current installation would consist of from 25 to 50 separate systems, each independent of defects on the rest, while in a continuous current installation a ground on the most remote branch circuit

rould, in conjunction with a ground on the opposite side f any other part of the system, form a short circuit.

The benefits of both the grounded and the ungrounded econdary system can be obtained by interposing a one to ne transformer in the secondary circuit. This transformer oes not alter the voltage but simply insulates the two parts

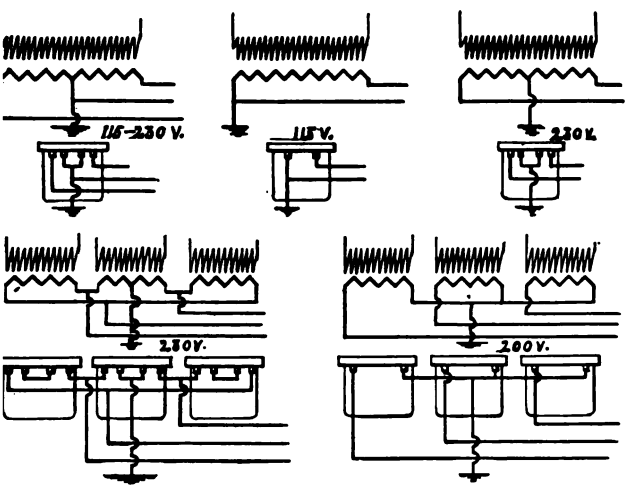


Figure 61.

f the secondary circuit. It is frequently used where the secndaries are especially liable to grounds as in packing houses nd breweries.

Methods of grounding secondary wires of alternating curent transformers are shown in Figure 61.

In connection with 3-wire systems, grounding of the neural wire can do little harm, because ordinarily the neutral

wire seldom carries much current, and that current is apt to vary in direction so that the electrolytic effect will be on the whole quite negligible.

In connection with 3-wire systems, however, it is of the greatest importance (as more fully explained further on) that the neutral wire remain intact, and it being thoroughly grounded at all available outside places will help to keep it so.

15. Grounding Low-Potential Circuits.

The grounding of low-potential circuits under the following regulations is only allowed when such circuits are so arranged that under normal conditions of service there will be no passage of current over the ground wire.

Direct-Current 3-Wire Systems.

a. Neutral wire may be grounded, and when grounded the following rules must be complied with:—

1. Must be permanently and effectively grounded at the Central Station. The ground connection must include all available underground water and gas pipe systems.
2. In underground systems the neutral wire must also be grounded at each distributing box through the box.
3. In overhead systems the neutral wire must be grounded every 500 feet, as provided in Sections *c* to *g*.

Inspection Departments having jurisdiction may *require* grounding if they deem it necessary.

Two-wire direct-current systems having no accessible neutral point are not to be grounded.

Alternating-Current Secondary Systems.

b. Tarnsformer secondaries of distributing systems should preferably be grounded, and when grounded, the following rules must be complied with:—

1. The grounding must be made at the neutral point or wire, whenever a neutral point or wire is accessible.
2. When no neutral point or wire is accessible, one side of the secondary circuit may be grounded, provided the maximum difference of potential be-

tween the grounded point and any other point in the circuit does not exceed 250 volts.

3. The ground connection must be at the transformers or on the individual service as provided in sections *c* to *g*, and when transformers feed systems with a neutral wire, the neutral wire must also be grounded at least every 500 feet.

Inspection Departments having jurisdiction may *require* grounding if they deem it necessary.

Ground Connections.

c. When the ground connection is inside of any building, or the ground wire is inside of, or attached to any building (except Central or Sub-stations), the ground wire must be of copper and have an approved rubber insulating covering National Electrical Code Standard, for from 0 to 600 volts.

d. The ground wire in direct-current 3-wire systems must not at Central Stations be smaller than the neutral wire and not smaller than No. 6 B. & S. gage elsewhere. The ground wire in alternating-current systems must never be less than No. 6 B. and S. gage.

On three-phase system, the ground wire must have a carrying capacity equal to that of any one of the three mains.

e. The ground wire should, except for Central Stations and transformer sub-stations, be kept outside of buildings as far as practicable, but may be directly attached to the building or pole by cleats or straps or on porcelain knobs. Staples must never be used. The wire must be carried in as nearly a straight line as practicable, avoiding kinks, coils and sharp bends, and must be protected when exposed to mechanical injury.

This protection can be secured by use of approved conduit or moulding, and as a rule the ground wire on the outside of a building should be in conduit or moulding at all places where it is within seven feet from the ground.

f. The ground connection for Central Stations, transformer sub-stations, and banks of transformers must be permanent and effective and must include all available underground piping systems including the lead sheath of underground cables.

g. For individual transformers and building services, the ground connection may be made as in Section *f*, or may be made to water piping systems running into buildings. This

be fastened by either screws or nails. If nails are used, they must be long enough to penetrate the woodwork not less than

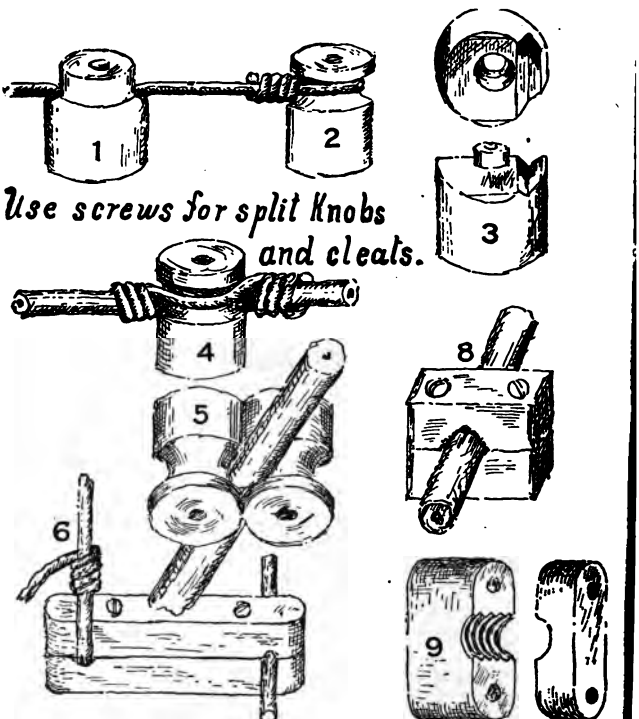


Figure 62.

one-half the length of the knob and fully the thickness of the cleat, and must be provided with washers which will prevent under reasonable usage, injury to the knobs or cleats.

s necessary where tie wires are used that they have an on the same as that of the conductor they confine. The e often cuts into the insulation of the line wire and if not insulated it would become alive. The larger bear- face given by the insulated wire will also reduce the of the tie wire cutting in.

merly it was customary to use a solid knob and tie all sizes of wire, but the present rule limits this type to wires of No. 8 and larger. The main objection tie wire, especially with wires of small size, was the

Figure 63.

of the tie wire becoming loose and letting the line ll from the knob. This objection is overcome in the ob where the wire is gripped directly by the porcelain self. At the ends of runs the split knob must not be t a solid knob as shown at (2), Figure 62, or a strain r as shown in Figure 63, may be used. Figure 62 ows other methods of supporting wires. At (4) is the manner of tying large wires of No. 8 B. & S. gage ger; (6), shows a knot tied into the wire as is usual the end of the wire connects into cut-outs or switches. insulators are arranged to hold large wires. It is not le to tie large wires to insulators as the weight of the ill soon cause it to cut through the insulation. Cleats are shown at (8) and (9) are preferable.

the rubber tape is put on before the wire has entirely cool the remaining heat will assist in vulcanizing the rubber. Tl rubber tape is then covered with friction tape to keep it place. Before taping joints the outer braid of the wire shou be carefully skinned back. If any of the cotton threads which it consists were to be left in contact with the bare wi they would, when moist, form a leak, which might prc troublesome. If joints are exposed to the weather it will well to paint them over with some insulating paint to k the friction tape in place, as it will otherwise soon work lo when it becomes dry.

At *c* and *d* "tap" joints are shown. The method sho at *d* is preferable, because the wire cannot easily work loc The method of joining shown at *e* is useful when, for stance, two wires, each of which is fastened to an insulat are to be joined. The wires can be drawn very tight in t way. This sort of joint is very common in fixture work, ; should be finished off as at *f*.

Twin wires other than flexible cord are allowed only metal conduits, and joints in them should be made o within the junction boxes. When joints in a twin wire unavoidable, the wires should be joined as at *g*, so that joints are not opposite each other. Joints in flexible c should be avoided.

In splicing stranded wires it is customary to remove sc of the center strands to avoid making a very bulky splice. stranded wires must be soldered where fastened under bi ing screws. The rule does not require the soldering of fl ible cords. Formerly this was required by the rules bu has been found that more harm than good is done for if soldering was not done very carefully the fine wire stra were made brittle and would break off. It was also fo that the insulation was destroyed for some distance from point of soldering. The lining of a socket should be so

gned as to thoroughly protect any stray strands which may ·otrude from the wire under the binding post from coming ı contact with the metal of the socket. If it is desired to ɔlder the ends of the cord before fastening under binding osts this is best done by dipping the ends into molten solder ıking care that the copper is cooled before it has had time ɔ heat the rubber insulation.

Figure 65 shows lead covered wire spliced and taped. In andling lead covered wire great care must be exercised (es-ecially with paper insulated) that it be not bruised and the ːad not punctured. The lead covering is of use only as a rotection against water; if it admits the least bit of mois-ıre it is worse than useless. In cutting the lead off from the nd of the cable great care should be taken that the insula-on is not injured. The best practice is to cut the lead only artly through then, by slightly bending the cable, break the ːad and pull it off.

The ends of lead covered wires should always be kept ːaled until ready for use; in damp places the paper insula-on may absorb moisture, which will ground the wire on the ad. When installed the ends should always be sealed against

Figure 65.

oisture. Lead covered wires should never be used where ere is a liability of nails being driven into them.

Joints in lead covered wires are made just as in ordinary ires. Extreme care is necessary that no moisture be left on e wire when it is taped or covered up. Before the wire is ined a sleeve (Figure 65) is slipped over one of the wires.

After the joint has been made and taped, this sleeve is placed so as to cover it, and the ends hammered down to fit close against the lead on the wires. That part of the lead which must be soldered to make the joint watertight is scraped until it is perfectly bright and then coated with tallow candle grease. It can then be soldered with an iron, or melted solder can be poured on it and wiped around it, as plumbers do. If a soldering iron is used it must not be too hot and not allowed to remain in one place too long, as the lead itself melts at nearly the same temperature as the solder. An inexperienced workman may burn more holes into the lead than he closes. If a neat job is desired, that part of the lead which is to be kept free of solder is covered with lampblack and glue, or ordinary paper hanger's paste, or a mixture of flour and water boiled, so as to prevent the solder from taking on it.

A Western Union joint, as shown in Figure 65, is somewhat objectionable in lead covered wires on account of the amount of space required by the joint itself. If this form of connection is used it is generally necessary to provide a lead sleeve somewhat larger than the outside diameter of the lead covering of the wire and the end of this sleeve must then be tapered down to conform to the lead covering. To overcome this objectionable feature joints are made as shown in Figure 66, where (a) shows a copper sleeve slipped over the ends

Figure 66.

of the wire, the whole being thoroughly soldered. The wires may be either butted together or lapped as shown by the dotted lines. In place of the metal sleeve the ends of the wire may be lapped and bound together by a small copper wir

own at (b), the whole being soldered; this, however, is as strong a joint as that made with a sleeve. Large ded cables are joined as shown at *a*, Figure 66 or they be joined as shown at the lower part of Figure 64.

Must be separated from contact with walls, floors, timor partitions through which they may pass by non-comble, non-absorptive, insulating tubes, such as glass or lain, except at outlets where approved flexible tubing is red.
ushings must be long enough to bush the entire length e hole in one continuous piece, or else the hole must first ushed by a continuous waterproof tube. This tube may conductor, such as iron pipe, but in that case an insulatbushing must be pushed into each end of it, extending nough to keep the wire absolutely out of contact with the

Where not enclosed in approved conduit, moulding or red cable and where liable to come in contact with gas, r, or other metallic piping or other conducting material, be separated therefrom by some continuous and firmly non-conductor creating a permanent separation. Must come nearer than 2 (two) inches to any other electric ing, power or signaling wire, not enclosed as above, with- being permanently separated therefrom by some contin- and firmly-fixed non-conductor. The non-conductor as a separator must be in addition to the regular insulaon the wires. Where tubes are used, they must be sely fastened at the ends to prevent them from moving the wire.
leviations from this rule may, when necessary, be allowed pecial permission.

he reasons for the separation of wires from everything their insulating supports are many. Should a bare live come in contact with damp woodwork or masonry, there ld very likely be some flow of current to ground and gh the ground to the other pole of the dynamo or other . This flow of current may gradually char the wood-, and in time start a fire; or it may gradually eat away

the wire, finally causing it to break. When a wire is eaten away, as shown at *c* and *e*, Figure 67, if it is carrying much current, the thin part will become very hot and will set fire to whatever inflammable material may be near it. If the current flow to the ground continues, the positive wire will finally be entirely severed, and an arc, similar to that noticed in an ordinary arc lamp, will be established, and will continue until the wire has been burned away and the space between the two

Figure 67.

ends becomes too great for the arc to maintain itself. The negative wire, to which the current flows, is not eaten away in this manner, and such current flow is only possible when two wires of a system are in electrical connection with the ground. This action may, however, occur, even if the two grounded wires are miles apart. Wires and gas pipes are often destroyed through intermittent contact; for instance, if a wire makes a good contact to a gas pipe and there is a small leak to the pipe no particular harm will be done as long as the contact remains good. Should, however, the contact be

intermittent, there will be a small arc at each break, and this will, little by little, burn holes into the gas pipe and into the wire. This action will take place on either a positive or negative wire. Non-combustible supports for wires are further useful in that they tend to prevent flames from the rubber insulation (which is very easily ignited from any of the above causes, from spreading to surrounding material.

Figure 67 consists of copies of specimens showing effects of electrolysis, short circuits, and heating of lamp. These illustrations are copied from fire reports of the National Board of Underwriters.

At *a* is shown a piece of gas pipe, which had been subject to electrolytic action until finally a hole had been eaten through the metal; *b* is a socket which had been short circuited, and the excessive damage was due to overfusing of circuit.

At *c* and *e*, the effects of electrolysis on wire are shown; *c* is a piece of underwriter's wire (not approved in moulding), which had been used in damp moulding, the leak to ground through the dampness causing the gradual eating away of the wire; *c* shows a breakdown in the insulation and subsequent electrolytic action on the wire causing it finally to break. This wire had been used in a roundhouse, where the sulphur fumes and the condensation of escaping steam on insulators had formed a path to ground. At *d* is an incandescent lamp which had been covered with a towel, the confined heat softening the glass and setting fire to the towel. The danger of fire from overheated lamps is much greater than is generally supposed. Small lamps and lamps subject to a little excess of voltage are especially dangerous, and many instances are on record where they have charred woodwork and set fire to cloth or paper shades.

It may in many cases seem unnecessary to have bushings in one piece long enough to pass through a floor, or wide

wall; but especially in passing through floors, it is easily possible for wires to become crossed between the joists; that is, the wire entering at the right above the floor may be brought out at the left below the floor and the other wire through the opposite holes. In such a case the two wires of opposite polarity will be in contact, and should the insulation give out from any cause whatever, such as abrasion, or the

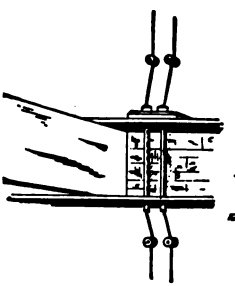


Figure 68.

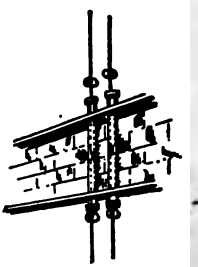


Figure 69.

Figure 70.

gnawing of rats and mice, there would be nothing to prevent a short circuit and consequent fire. In passing through floors or walls the wires often come in contact with concealed pipes or other grounded material, so that only by making the bushings continuous as shown in Figure 68 can the wires be properly protected.

Figure 69 shows short bushings arranged in iron pipe. Figure 70 shows a case where there is an offset in the wall. Cases of this kind very often occur. Sometimes the floor can be taken up and an iron conduit, properly bent, put in place; the wires being reinforced with flexible tubing; or the wires placed on insulators. In this latter case the floor must not be put down until the inspector has examined the wires. The

the most dangerous, can then be tightly enclosed, as it will seldom be necessary to get at them. In practice it has been found almost impossible to keep the doors of cabinets which are much used closed. It seems next to impossible to construct a cabinet which is dustproof, with a door that can be readily opened, and a self-closing door can hardly be made to remain dustproof. Doors are made self-closing either through gravity or by suitable springs.

As switch and cut-out boxes are very likely to be used for the storage of cotton waste, paper, etc., which would readily

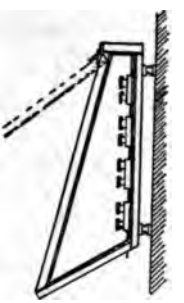


Figure 77.

ignite from a melted fuse, it would be well to construct them with a slanting bottom as indicated in Figure 77, so that nothing will lie in them.

A cut-out box of very good design is shown in Figure 77. The door closes by gravity and the manner in which it lies against the cabinet causes it to close more securely than it would if hung perpendicularly.

c. Must, when exposed to dampness, either be enclosed in a moisture-proof box or mounted on porcelain knobs. The

preferable. Insulating supports should always be provided at the place of crossing to prevent the upper wires from sagging and resting on the lower; also to prevent any strain from coming on tap joints. Approved flexible tubing such as circular loom is also often used in crossing wires and pipes. In

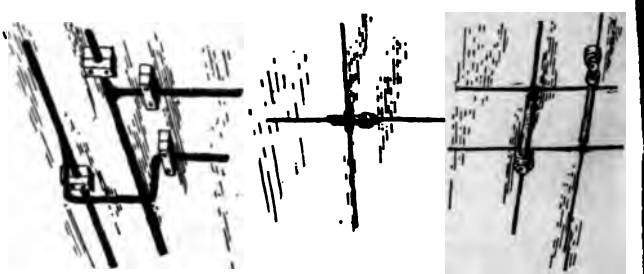


Figure 72.

dry locations it is quite safe and does not break as easily as tubes, but should never be used where there is any likelihood of dampness.

f. Must be so placed in wet places that an air space will be left between conductors and pipes in crossing, and the former must be run in such a way that they cannot come in contact with the pipe accidentally. Wires should be run over rather than under pipes upon which moisture is likely to gather or which, by leaking, might cause trouble on a circuit.

This is a rule that is very often violated, as much work is done using loom, as shown at the left of Figure 73, and is quite safe with gas pipes. With cold water pipes, which are likely to sweat, or with steam pipes, it is very bad practice. Where pipes are close against a ceiling it is better either to fish over them or drop wires some distance below them as illustrated at the right of the figure. No part of the wiring

ıould be in contact with pipes. On side walls where vertical ires run across horizontal pipes the only safeguard would : to box the pipes and run the moisture to one side. The ost harm is done by water on the insulators. If these can kept dry it does not matter much about wires which hang ee in the air. Whatever form of insulation is used in cross- g pipes, it must be continuous. Short bushings strung on e wire, where a large pipe or number of pipes are being ɔssed, is not satisfactory, as the bushings are apt to separate

Figure 73.

moisture gather in the space between them. The insula- n must also be firmly attached to the wires. If knobs are t used as shown in Figure 72 to keep the bushings in place, ey must be taped to the wire.

g. The installation of electrical conductors in wooden ɔuilding, or on insulators, in elevator shafts will not be ap- ɔved, but conductors may be installed in such shafts if en- ɜed in approved metal conduits, or armored cable.

Wires supported on insulators in such places are very likely be disturbed, especially in freight elevators. Moulding is ten so impregnated with oil and the draft in an elevator aft is usually so strong that a blaze once started would ickly run to the top.

Underground Conductors.

a. Must be protected against moisture and mechanical in- y where brought into a building, and all combustible ma- ial must be kept from the immediate vicinity.

b. Must not be so arranged as to shunt the current ough a building around any catch-box.

By reference to Figure 74 the meaning of this rule will be made clear. With wire run as shown it would be easy for any one having disconnected one service switch to believe all wires in the building dead, while they were in reality still being kept alive by the other switch. This connection would allow current to pass from one street main to another without going through the fuses in the street catch-box.

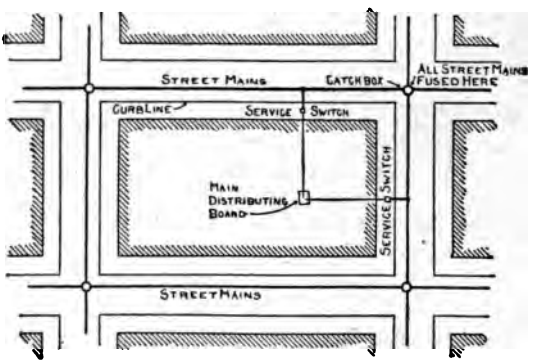


Figure 74.

c. Where underground service enters building through tubes, the tubes shall be tightly closed at outlets with asphaltum or other non-conductor, to prevent gases from entering the building through such channels.

d. No underground service from a subway to a building shall supply more than one building except by written permission from the Inspection Department having jurisdiction.

18. Table of Carrying Capacity of Wires.

(See tables in back of book.)

19. Switches, Cut-outs, Circuit-Breakers, Etc.

a. On constant potential circuits, all service switches and all switches controlling circuits supplying current to motors

or heating devices, and all fuses, unless otherwise provided (for exceptions as to switches see Nos. 8 *c*, 25 *a* and 43 *c*; for exceptions as to cut-outs see No. 23 *a* and *b*, must be so arranged that the fuses will protect and the opening of the switch will disconnect all of the wires; that is, in the two-wire system the two wires, and the three-wire system the three wires, must be protected by the fuses and disconnected by the operation of the switch.

When installed without other automatic overload protective devices automatic overload circuit breakers must have the poles and trip coils so arranged as to afford complete protection against overloads and short circuits, and if also used in place of the switch must be so arranged that no one pole can be opened manually without disconnecting all the wires.

This, of course, does not apply to the grounded circuit of street railway systems.

The exceptions for switches are for motors of ¼ H. P. or less on circuits where the voltage does not exceed 300, electric heaters requiring not more than 660 watts and electric cranes. In the first two cases single pole switches may be used and in the case of cranes switches need not be provided for each individual motor. The exception for cut-outs is for mains where the fuse is omitted in the neutral wire.

In connecting double pole snap switches the wireman should be very careful. Most of these switches cross polarities as shown in Figure 75, and if connected wrong will form short circuits. Many of them have been connected this way even by wiremen of some experience.

b. Must not be placed where exposed to mechanical injury nor in the immediate vicinity of easily ignitible stuff or where exposed to inflammable gases or dust or to flyings of combustible material.

Where the occupancy of a building is such that switches, cut-outs, etc., cannot be located so as not to be exposed as above, they must be enclosed in approved dust-proof cabinets with self-closing doors, except oil switches and circuit breakers which have dust-tight casings.

What is known as concealed knob and tube work is not allowed in wiring for high tension arcs; neither can the wires be run in moulding or conduit.

It has been customary to use no smaller than No. 6 wire for these high tension series circuits. The current required is seldom more than 10 amperes, and No. 14 wire has sufficient carrying capacity, but its mechanical strength is not very great. The danger from a broken wire in high tension systems is much greater than in low tension systems, because of the long arc which occur at the break. The loss in volts per 100 feet with No. 6 will be about .4, while with No. 14 it will be 2.6. While this will not affect the lights, the pressure at the generator being correspondingly increased, the question of drop is of importance. On a circuit 10 miles long a No. 14 wire would have a drop of 1372 volts and a No. 6 wire a drop of 211 volts.

d. Must be supported on glass or porcelain insulators, which separate the wire at least one inch from the surface wired over, and must be kept *rigidly* at least eight inches from each other, except within the structure of lamps, on hanger-boards or in cut-out boxes, or like places, where a less distance is necessary.

An extra precaution often taken in this kind of work on plastered walls is to place a wooden block or rosette about three inches in diameter and one-half inch thick under each insulator; this secures greater separation from ceilings and side walls and adds greatly to the stability of the insulators. On plastered walls a small insulator, if subjected to side strain, will cut into the plaster on one side and allow the wires to sag; the wooden block will prevent this.

e. Must, on side wall, be protected from mechanical injury by a substantial boxing, retaining an air space of one inch around the conductors, closed at the top (the wires passing through bushed holes), and extending not less than seven feet from the floor. When crossing floor timbers in cellars,

rooms where they might be exposed to injury, wires
be attached by their insulating supports to the under
a wooden strip not less than one-half an inch in thick-
Instead of the running-boards, guard strips on each
and close to the wires will be accepted. These strips

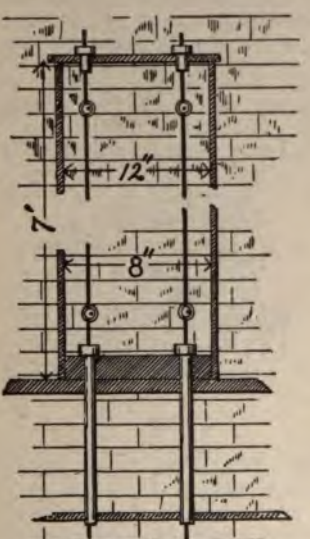


Figure 80.

not less than seven-eighths of an inch in thickness and
t as high as the insulators.

ure 80 is an illustration of protection on side walls,
the dimensions required for high tension. The wooden
shown, which raises bushings above floor, is an extra
ion to prevent water from running into them.

21. Series Arc Lamps.

(For construction of Arc Lamps, see No. 74.)

a. Must be carefully isolated from inflammable materi

b. Must be provided at all times with a glass globe s rounding the arc, and securely fastened upon a closed ba Broken or cracked globes must not be used.

c. Must be provided with a wire netting (having a me not exceeding one and one-fourth inches) around the glo and an *approved* spark arrester (see No. 75), when rea inflammable material is in the vicinity of the lamps, to prev escape of sparks of carbon or melted copper.

Outside arc lamps must be suspended at least eight fe

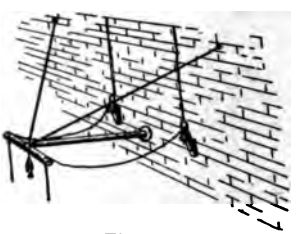


Figure 81.

above sidewalks. Inside arc lamps must be placed out o reach or suitably protected.

Arc lamps, when used in places where they are expose to flyings of easily inflammable material, must have the car bons enclosed completely in a tight globe in such manner a to avoid the necessity for spark arresters.

"Enclosed arc" lamps, having tight inner globes, may b used, and the requirements of Sections *b* and *c* above would, of course, not apply to them.

d. Where hanger-boards are not used, lamps must be hung from insulating supports other than their conductors.

e. Lamps when arranged to be raised and lowered either for carboning or other purposes, shall be connected up with stranded conductors from the last point of support to the lamp, when such conductor is larger than No. 14 B. & S. gage

Figure 81 shows the usual method of suspending outdoor arc lamps on buildings. The supporting wire may be fastened to brick or stone walls by drilling a hole about four inches deep and plugging this securely with wood, when an eye or lag bolt or large spike may be driven or screwed into it. Expansion bolts, of which there are many kinds to be had, may also be used and are preferable in most cases. It is best to arrange the supporting wires at quite a high angle, otherwise the direct outward pull may be too great.

On very low ceilings, lamps are often arranged as shown at Figure 82, the plastering being cut away and lamp sus-

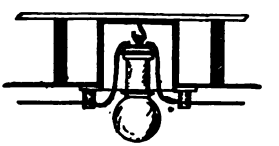


Figure 82.

pended from floor above joists. The space above plaster must be enclosed on all sides and all woodwork protected with asbestos board at least one-eighth inch thick.

If this method is used with constant potential arc lamps carrying resistance in the hood, it would be well to remove or short-circuit this resistance and locate another in a more suitable place.

A stranded wire is required for lamps that are to be raised or lowered as the constant movement of the wires due either to the raising or lowering of the lamp for recarboning or the swinging of the wires by the wind is liable to cause them to break and form an arc inside the insulation.

22. Incandescent Lamps in Series Circuits.

a. Must have the conductors installed as required in No. 20, and each lamp must be provided with an automatic cut-out.

b. Must have each lamp suspended from a hanger-board (see No. 73) by means of rigid tube.

c. No electro-magnetic device for switches and no multiple-series or series-multiple system of lighting will be approved.

d. Must not under any circumstances be attached to gas fixtures.

Some years ago carbon filament series incandescent lamps were frequently used for street lighting, especially in small towns and in the residence districts of cities. These lamps were operated in series direct from the primary circuits with either automatic cutouts at the lamps or an arrangement in the plant whereby additional lamps could be switched in on the circuit as lamps burned out on the line. They were also operated in connection with series arc lamps on the same circuits. They were seldom used for inside lighting. None of these systems proved very satisfactory.

With the advent of the tungsten lamp the use of series lighting has greatly increased for the purposes mentioned. These lamps may be obtained of various candle powers and are made with a very rugged filament. They are operated in series on alternating current circuits with current transformers or current regulators.

Each lamp is inserted in a special socket such as is shown in Figure 83. The socket is constructed of porcelain so that it is perfectly weatherproof and is provided with a pair of metal prongs arranged to fit into the receptacle as shown. Inserted between the prongs is a thin film of shellac or mica. Current flows from the contacts on the receptacle through one of the prongs to the lamp and out through the other prong. If the lamp burns out an excessive voltage is impressed on the terminals and the insulating film is broken down the circuit being then completed directly through the metal prongs.

The socket may be removed from the receptacle in which ase the circuit closes automatically by the spring clips of the eceptacle coming together. A new lamp may then be inserted nd a new film placed between the prongs and the lamp then ut in service. Removing the lamp from the socket allows the pring contact inside the socket to close the circuit so that the

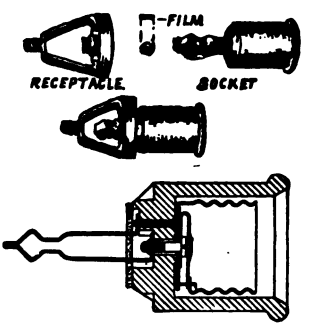


Figure 83.

lamps may be changed at will. The automatic film will break lown at a potential of about 400 volts.

The same precautions for handling these circuit must be bserved as mentioned in the case of series arcs.

Considerable discussion has arisen at times in regard to the ule restricting series-multiple or multiple-series systems of ighting. This rule has been applied to low potential systems ircuits but it will be noted that it comes under the head of onstant current systems (principally series arc lighting) and was not intended to refer to the ordinary low potential ystems.

The table given below gives data on the Mazda Street eries lamps.

MAZDA STREET SERIES LAMPS.

Ampere Range	Candle-power	Average Total Watts	Average Volts	W P. C.	% Spherical of Horizontal Candle-power	Total Lumens	Hours Life
4.0 (3.9 to 4.3)	32	37.8	9 5	1.18	78.8	315	1500
	60	70.8	17.7	1 18		560	
	100	118.0	29.5	1.18		934	
	200	236 0	59.0	1.18		1868	
	500	413.0	103.3	1.18		3443	
5.5 (5.1 to 5.9)	32	37 8	6.9	1.18	78.8	315	1500
	60	70.8	12.9	1.18		560	
	100	118.0	21.4	1.18		934	
	200	236.0	42.9	1.18		1868	
	500	413.0	75.1	1.18		3443	
6 6 (6.1 to 6.9)	32	37.8	5.7	1.18	78.8	315	1500
	60	70.8	10.7	1.18		560	
	100	118.0	17.9	1.18		934	
	200	236.0	35.8	1.18		1868	
	500	413.0	62.6	1.18		3443	

CONSTANT-POTENTIAL SYSTEMS.

General Rules—All Voltages.

Automatic Cut-Out (Fuses and Circuit-Breakers).

(See also No. 19. For construction rules see Nos. 66 and 67.)

The fuse is the principal protective device used in electric ght and power work. In its simplest form it consists of a ece of wire made of a certain alloy designed to melt at comparatively low temperature. It is so connected in the rcuit that all the current must pass through it. We have ready seen that currents of electricity generate heat in the nductors through which they pass, and that this heat is pro-ortional to the square of the current flowing; that is, if we ouble the current we shall increase the production of heat ourfold. A dangerous rise in current strength may be due a "short circuit" or to an overload, too many lamps or otors being connected to a circuit. To prevent damage to ires and other apparatus from excessive currents, fuses or t-outs must be installed. When the current rises above its llowed strength the fuse melts and opens the circuit; that stops all current flow. The melting of the fuse is accom-anied by a flash of fire due to the arc which is set up across e break in the fuse wire. On an ordinary overload with the naller size fuses this arc may not be very severe, but with e larger size fuses and on short circuits a very severe flash nd explosion may result and molten metal may be thrown r some distance from the fuse. This explosion is caused by e outer layers of metal of the fuse remaining cool and in solid state while the metal at the center of the fuse is first elted and then vaporized.

Another device which is used for the same purpose as the

fuse is known as the circuit-breaker. A circuit-breaker in its simplest form comprises a knife switch which when closed is forced in against a spring and held in place by means of a small catch. A solenoid, inside of which is placed a moveable iron core, is connected in series with one side of the switch. When the current passing through this solenoid exceeds a certain amount, the iron core is drawn up into it, and, striking against the catch, releases the switch which will then fly open, thus cutting off the current. The core of this solenoid is so designed that when it starts to move its speed is greatly accelerated so that it strikes the catch a sharp blow. By means of a small adjusting screw the circuit-breaker can be set to operate at various current strengths within its limits. For this reason and for the further reason that it is so easily made inoperative by tying or blocking its solenoid it is not approved for general use unless fuses are also installed. It may be used under the care of a competent electrician who understands the dangers of its abuse.

Under these conditions its use is to be strongly recommended. Where not so used fuses must also be provided in the same circuit with the circuit breaker. For further information in reference to the use of circuit breakers see section on Generators, Page 58.

a. Must be placed on all service wires, either overhead or underground, in the nearest accessible place to the point where they enter the building and inside the walls, and arranged to cut off the entire current from the building.

Where the switch required by No. 24 *a* is inside the building, the cut-out required by this section must be placed so as to protect it.

For three-wire (not three-phase) systems the fuse in the neutral wire may be omitted, provided the neutral wire is of equal carrying capacity to the larger of the outside wires, and is grounded as provided for in No. 15.

In risks having private plants, the yard wires running from building to building are not considered as service wires, so

that cut-outs would not be required where the wires enter buildings, provided that the next fuse back is small enough to properly protect the wires inside the building in question.

The fuse block here required serves a double purpose; it affords protection to the whole installation while in use, and is an effective means of disconnecting a building when current is no longer used. This can also be accomplished by means of the service switch, but a switch is so easily closed by any one that it must never be relied upon entirely for this purpose.

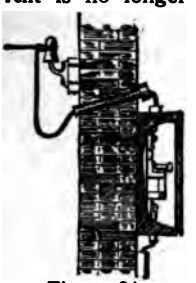


Figure 84.

Figure 84 shows arrangement of fuses and switch as commonly installed where wires enter buildings. The wires enter at the top, connect to the fuse terminals, current passing through the fuses to the switch.

This rule allows the neutral fuse to be omitted on three-wire systems where the neutral is grounded and where the neutral wire is of as great carrying capacity as the larger of the outside wires. On three-wire systems where the neutral wire is not grounded, as in the case of some isolated plants, fuses must be placed in all three wires, including the neutral wire. The reason for this is obvious. A ground coming on any part of the neutral wire of a three-wire grounded system cannot cause a short circuit. Referring to Figure 85, G shows the permanent ground and B a ground on any other point on the neutral wire. It is plain that the ground B cannot cause a short circuit, and the fuse in this wire may, therefore, be omitted. A ground coming on either of the outside wires, at A for instance, would be cleared by the fuse protecting that wire. In a system with an ungrounded neutral a single ground coming on one of the outside wires, as at G′ for instance, would not cause a short cir-

cuit, but if the outside wire was grounded at G′ and a ground should come on the neutral wire, at B for instance, a short circuit would immediately result and the neutral wire would probably be destroyed owing to the fact that there is no fuse to protect it.

If the fuse is omitted in the neutral wire and a fuse on one of the outside mains should blow, the neutral wire would then be called upon to carry the same amount of current as was being carried in the remaining outside wire. For this

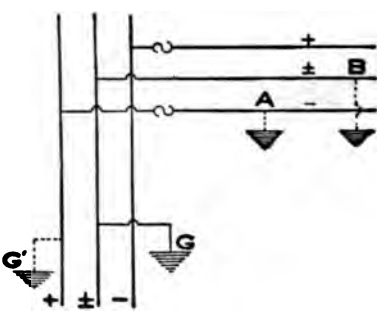


Figure 85.

reason the neutral wire must be of as great carrying capacity as the larger of the outside wires.

The danger arising from the blowing of the neutral fuse (which this rule is designed to prevent) is described under the next rule, 23 *b*.

b. Must be placed at every point where a change is made in the size of wire [unless the cut-out in the larger wire will protect the smaller (See Table of Carrying Capacity)].

For three-wire direct current or single phase systems the fuse in the neutral wire except that called for under No. 23 *d*,

ıy be omitted, provided the neutral wire is grounded as pro-ıed for in No. 15.

Figure 86, A to D, shows systems of distribution and ar-ngement of mains in general use. Figure A shows the mplest and cheapest method of running mains, and is known the "tree system." Beginning at the service the wires ust be large enough to carry the whole amount of current ıed to the first floor or wherever the first cut-out center is cated. At this point the size of wire may be reduced be-ıuse it will be required to carry only the current used further ı. Main cut-outs should be arranged as shown in the figure : 1 and 2. That is, the cut-outs protecting the mains must ɔ installed in the mains at each floor after the current for ıat floor has been taken off. Cases are often found where ıe cut-out is placed in the main line, ahead of the branch locks. This is obviously wrong, as the fuse will have to be ɔo heavy to protect the smaller mains.

Figure B shows a somewhat different arrangement which ɔquires more wire and is more expensive in the beginning, ut far more satisfactory and economical in operation. With ıe wires arranged as shown in the diagram the pressure at ll the lamps will be nearly uniform. Even if the mains are esigned for a considerable loss to the center of distribution ıe dynamo may be made to compensate for this loss and eep the lamps burning properly. With the tree system, A, ıis is impossible; the lamps at the first cut-out center will ither be too bright or those at the last center too dim.

Figure C shows a convertible three-wire system.

In order to convert a three-wire system into a two-wire ystem the two outside wires are joined together. The mid-le wire then forms one side of the system and the outside ires the other. The middle wire must carry as much cur-ent as both outside wires combined and should have a carry-ıg capacity equal to them. It should be remembered that a

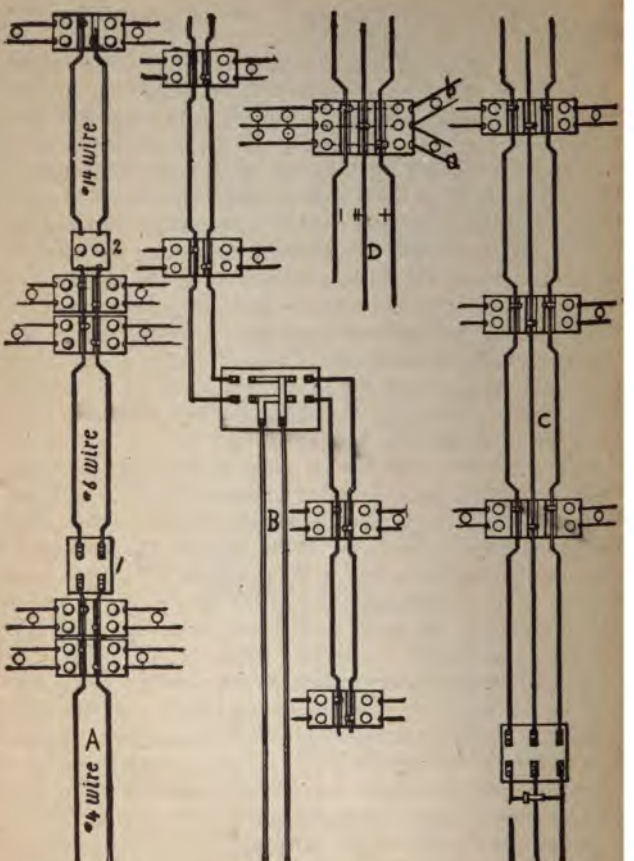


Figure 86.

ire containing simply twice as many circular mils does not lfill this requirement, as is shown in Table No. 1 on page 421, hich must be consulted in selecting wires.

In three-wire systems the middle or neutral wire is merely balancing wire and normally carries very little or no cur-:nt, but it is very important that it remain intact. If for in-ance in Figure D the branch circuit *a* has twelve lights ırning while there are also twelve lights burning on *b*, the ırrent will pass from the positive wire through the lower ıse to *a*, through the twelve lights in *a* back to the middle ıse, thence through the twelve lights in *b* to the upper fuse ıd negative wire, the two sets of lamps burning in series. now the lamps in *b* are switched off the current from *a* can ɔ longer pass through them and instead returns through the iddle fuse to the neutral wire. If only six lights in *b* are ırning, while twelve are burning in *a*, the current of six ghts will return over the negative wire and the other six ı *a* will return over the neutral wire. Should the neutral ire be broken or its fuse blown there would be no return ıth on it for the extra current, and consequently the cur-:nt passing through the twelve lights in *a* would be forced ɔ pass through the six lights in *b*, causing them to burn ith excessive brilliancy and to break in a very short time. hould a short circuit occur, say on circuit *b*, with the neu-al wire intact, it would merely blow out a fuse, but if the ıain neutral fuse were out it would bring 220 volts on cir-ıit *a* and speedily cause damage to the lamps. Thus it ill be seen that it is of great importance to fuse the neutral ire so that it will not easily blow out.

Figure C shows a system of wiring quite often used. A :t of heavy mains are run from the service or dynamo to ıe top floor and taps taken off at each floor. These mains ɔ not change size at each floor, but are continuous for their ıtire length. While this method has some of the objections

of the tree system in regard to voltage, still the faults
tree system are greatly reduced owing to the much s
losses in the mains between the upper floors, or those f

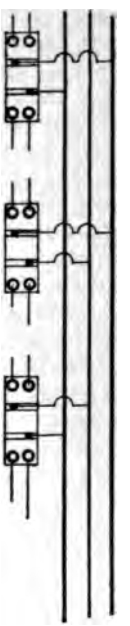
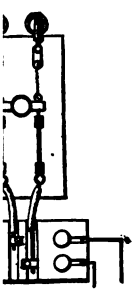


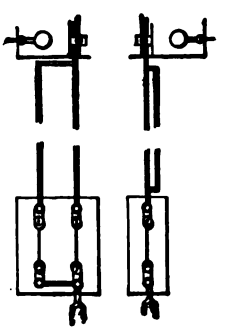
Figure 87.

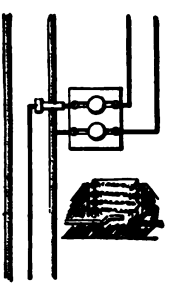
from the dynamo. Figure 87 shows a set of three
risers with branch circuit taps.

Figure 88 shows the method of fusing main switc
branch circuits. The switch itself will require a fuse t
tect it, although it need not be right at the switch.

iten becomes necessary to reinforce a set of mains, y for motors, which have become overloaded, by run- other wire in parallel with the old, as indicated in 89 and 90. Two separate and distinct ways of ar- them are shown and it depends upon the conditions hich is preferable. If the wires are small or run in /here they are liable to be broken, the plan shown in 89 is the better. Here each wire is properly fused and)reaks the other carries the whole load until its fuse If the wires, as often happens, are much overfused, aking of one wire would force the other to carry)le current and become overheated. If the arrange-







88. Fig. 89. Fig. 90. Figure 91.

ere as in Figure 90 the unbroken wire would carry the indefinitely and soon become overheated. On the and, if both wires are large and the run is short the rranged as in Figure 89 may, through poor contacts, one or the other of the wires from obtaining its are of the current. The fuse making poor contact force a much greater share of current through the

other wire. In most cases the better plan would be to arrange the wires as in Figure 90. If the current supplied is for lights the branch cut-outs can be separated and each set of mains allowed to supply a certain part of them, when each set should be made independent. For sizes of wires to be used for reinforcing, see Tables.

With the three-wire system where a large motor load and but few lights are used the lights are often fused as shown

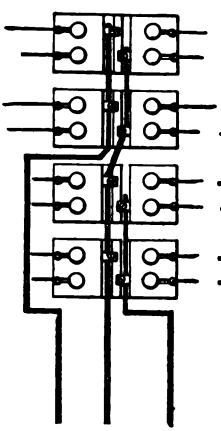


Figure 92.

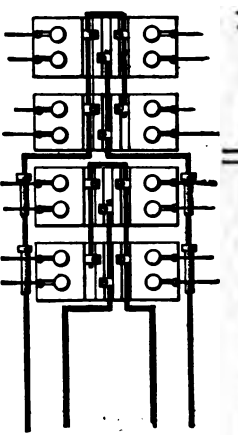


Figure 93.

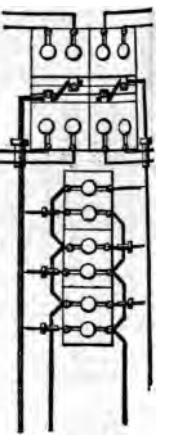


Figure 94.

in Figure 91, a small wire being run for the neutral, t smaller wire, of course, being properly fused at the main c out. Plug cut-outs of the type shown in this figure oft have the metal parts projecting above the porcelain; th should be connected so that the metal parts which project a dead when the plugs are removed. This will prevent ma short circuits on disconnected cut-outs.

Figure 92 shows the method of converting a two-wire stem into a three-wire system with one extra wire to run. his extra wire will very likely not need to be as large as the her wires are, because the three-wire system requires only e-half as much current and it should, therefore, be used as e neutral. This arrangement will secure the full benefit of l the copper in the old wires (which are probably much rger than necessary) and will operate at a very small loss.

Figure 93 shows a straight three-wire system changed to two-wire system, one extra wire run for it. If the three vires are of the proper capacity the addition of the fourth vire as in the figure will make it correct for two-wire systems, the mains feeding the upper and lower groups being, of course, properly fused where they start.

In Figure 94 the cut-outs are so connected that all branch wires leaving the cut-out box at either side are of the same polarity. This is often useful where many wires are to be run close together.

Connections to three-phase systems are made as shown in Figures 95 and 96.

Figure 95 shows the proper method of connecting plug cut-outs in "delta," and Figure 96 the connections for "star."

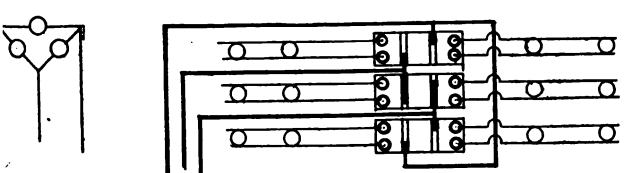


Figure 95.

The broken line indicates a balancing wire the office of which is somewhat similar to that of the neutral wire in a three-wire system. There are *many* cases in use where three-phase sys-

for switches, and also for fixtures which are not attached to gas pipes or conduit.

Figure 100 shows concealed wiring back of lathing leading to a double-pole flush switch. The board fastened between studdings must be cut out to admit the box of switch and the size of this box should be known when wires are put in. The board should not rest hard against the lathing, but leave a little space for plaster to work in behind the lath.

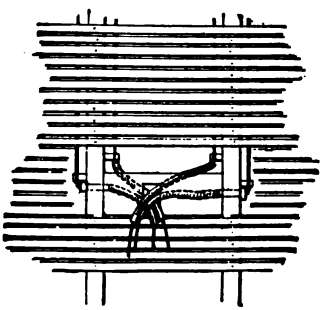


Figure 100.

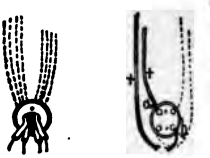


Figure 101.

Loom is put on all wires at outlets and must extend back to the nearest knob.

Figure 101 shows two methods of fastening snap switches by means of wooden blocks first fastened to the plaster. One block is cut out so as to bring all wires under the switch and entirely conceal them. The opening in block to admit wires and bushings should be oblong, so as to leave room on two sides for the screws with which the switch is to be fastened. On the other block the wires and bushing are brought through close to the outer edge of switch base. By careful workmanship a neat job can be done in this way. *As most snap* switches cross conductors, that is, connect

points *a* and *b*, if from the nature of the case it becomes necessary to run any of the wires close together these two wires may be run that way, for they can never be of opposite polarity.

f. Sub-bases of non-combustible, non-absorptive, insulating material, which will separate the wires at least one-half inch from the surface wired over, must be installed under all snap switches used in exposed knob and cleat work. Sub-bases must also be used in moulding work, but they may be made of hardwood or they may be omitted if the switch is approved for mounting directly on the moulding.

25. Electric Heaters.

It is often desirable to connect in multiple with the heaters and between the heater and the switch controlling same an incandescent lamp of low candle power, as it shows at a glance whether or not the switch is open and tends to prevent its being left closed through oversight.

a. Must be protected by a cut-out and controlled by indicating switches. Switches must be double pole except when the device controlled does not require more than 660 watts of energy.

b. Must never be concealed, but must at all times be in plain sight.

Special permission may be given in writing by the Inspection Department having jurisdiction for departure from this rule.

c. Flexible conductors for smoothing irons and sad irons, and for all devices requiring over 250 watts must have an *approved* insulation and covering.

d. For portable heating devices the flexible conductors must be connected to an *approved* plug device, so arranged that the plug will pull out and open the circuit in case any abnormal strain is put on the flexible conductor. This device may be stationary, or it may be placed in the cord itself. The cable or cord must be attached to the heating apparatus in such manner that it will be protected from kinking, chafing or like injury at or near the point of connection.

e. Smoothing irons, sad irons, and other heating appliances that are intended to be applied to inflammable articles, such as clothing, must conform to the above rules so far as they apply. They must also be provided with an approved stand, *on which they should* be placed when not in use.

f. Stationary electric heating apparatus, such as radiators, ranges, plate warmers, etc., must be placed in a safe location, isolated from inflammable materials, and be treated as sources of heat.

Devices of this description will often require a suitable heat-resisting material placed between the device and its surroundings. Such protection may best be secured by installing two or more plates of tin or sheet steel with a one-inch air space between or by alternate layers of sheet steel and asbestos with a similar air space.

g. Must each be provided with name-plate, giving the maker's name and the normal capacity in volts and amperes.

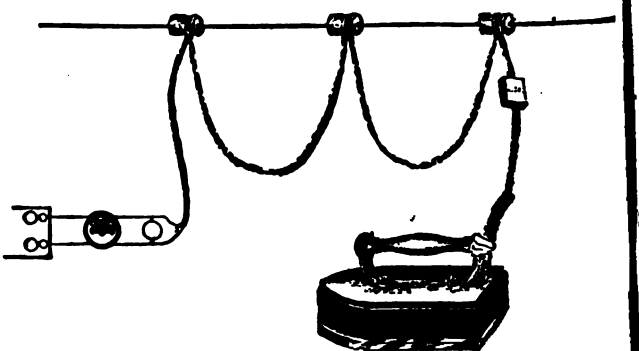


Figure 102.

In Figure 102 is given a diagram of a heater circuit with a 4 c. p. lamp in circuit. Where there are many irons in use, as in some tailoring establishments, it is advisable to run them all from one set of mains with a main switch convenient to exit door and have this switch opened whenever the irons are not in use. The individual switch at each iron should be located as near as possible to each iron. Cords feeding irons or cloth cutting machines are often installed as shown, insulators are strung on a tight wire and the cord tied to them. This allows considerable latitude in moving the iron.

LOW-POTENTIAL SYSTEMS.

550 VOLTS OR LESS.

circuit attached to any machine, or combination of machines, which develops a difference of potential between ny two wires, of over ten volts and less than 550 volts, hall be considered as a low-potential circuit, and as coming nder this class, unless an approved transforming device is sed, which cuts the difference of potential down to ten olts or less. The primary circuit not to exceed a potenial of 3,500 volts, unless the primary wires are installed n accordance with the requirements as given in No. 13, or re underground. For 550 volt motor equipments a marin of ten per cent above the 550 volt limit will be allowed t the generator or transformer.

Wires.

GENERAL RULES.

e also Nos. 16, 17, 18 and 27. For construction rules see Nos. 49 to 57.)

. Where entering cabinetes must be protected by apred bushings, which fit tightly the holes in the box and are secured in place. The wires should completely fill the s in the bushings so as to keep out the dust, tape being l to build up the wires if necessary. On concealed knob tube work approved flexible tubing will be accepted in of bushings, providing it shall extend from the last porin support into the cabinet.

. Must not be laid in plaster, cement or similar finish, must never be fastened with staples.

. Must not be fished for any great distance, and only in es where the inspector can satisfy himself that the rules e been complied with.

Figure 103 illustrates a very common combination of "fish" "moulding" work. Moulding is used to bring the wires

from the floor to the ceiling and along the ceiling to a point opposite the outlet and parallel with the joists. From this point to the fixture the wires can then be readily fished.

The connection between the fish and moulding work should be made as shown at the right, where the moulding is cut

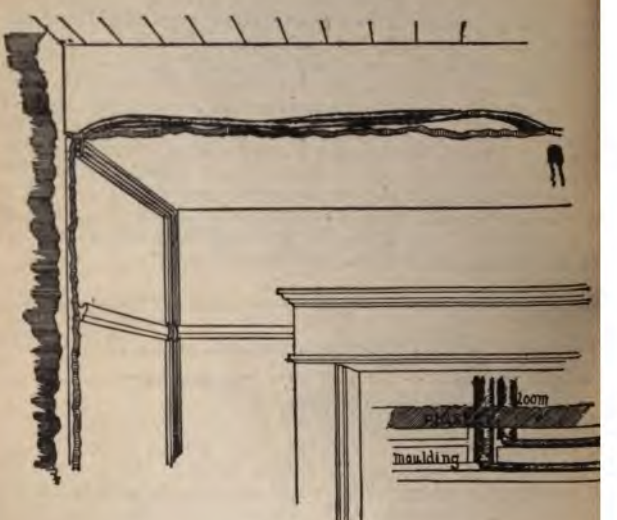


Figure 103.

out so as to admit the loom. It is better, even, to have the loom show to some extent than to have the wire come in contact with the plaster, as will very likely be the case if the loom is not fully brought through.

d. Twin wires must never be used, except in conduits, where flexible conductors are necessary.

Flexible conductors are in general considered necessary
ly with pendant sockets, certain styles of adjustable brack-
, portable lamps, motors and stage plugs, or heating ap-
ratus.

e. Must where exposed to mechanical injury be suitably
otected. When crossing floor timbers in cellars, or in rooms
ere they might be exposed to injury, wires must be at-
ched by their insulating supports to the under side of a
oden strip, not less than one-half inch in thickness, and
t less than three inches in width. Instead of the running
ards, guard strips on each side of and close to the wires
ll be accepted. These strips to be not less than seven-
hths of an inch in thickness and at least as high as the
ulators.

Protection on side walls must extend not less than five
et from the floor and must consist of substantial boxing,

Figure 104.

retaining an air space of one inch around the conductors,
closed at the top (the wires passing through bushed holes)
or *approved* metal conduit or pipe of equivalent strength.

When metal conduit or pipe is used, the insulation of each
wire must be reinforced by *approved* flexible tubing extending
from the insulator next below the pipe to the one next above
it, unless the conduit is installed according to No. 28 (Sections
c and *f* excepted), and the wire is approved for conduit use.
The two or more wires of a circuit *each* with its flexible tub-

ing (when required), if carrying alternating current *must*, if direct current, *may* be placed within the same pipe.

In damp places the wooden boxing may be preferable bec of the precautions which would be necessary to secure proper sulation if the pipe were used. With this exception, however, piping is considered preferable to the wooden boxing, and its is strongly urged. It is especially suitable for the protection wires near belts, pulleys, etc.

Figure 104 illustrates the meaning of the rule in reg to wires run along low ceilings.

Figure 105 gives the dimensions necessary for the b ing surrounding wires on side walls. The figure also sho

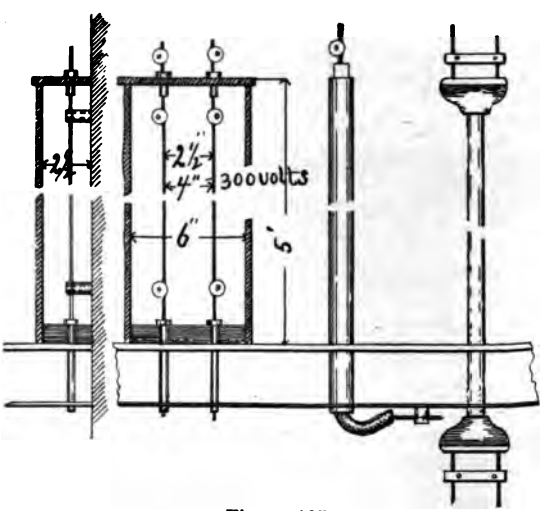


Figure 105.

the method of running wires in common iron pipe such steam pipe. In this case the wires are each protected by additional covering of flexible tubing. At the right of the

; shown the more common method of using conduit for
rotection of the wires. Approved conduit with outlet
;s at each end is securely fastened in place. Double
, rubber covered wire, such as is required for conduit
must be used. The sections of the rule governing con-
work which do not apply in this case are: the wire may
illed in before the mechanical work on the building is
leted, and, it is not necessary to ground the conduit. This
od of protecting wires is very satisfactory and is often
around belts and around machinery. Where the con-
is are such as to require protection in a number of places
often better to use single wires, each with a double braid,
is will do away with the necessity of splicing short lengths
uble braid wire where passing through the short lengths
nduit.

When run in unfinished attics, will be considered as
aled, and when run in close proximity to water tanks or
will be considered as exposed to moisture.
unfinished attics, wires are considered as exposed to me-
cal injury, and must not be run on knobs on upper edge
ists.

he question sometimes arises as to what is an "unfin-
attic." In general an attic may be considered as un-
ed when it is not provided with a floor and also with a
anent stairway leading to it. Attics are generally used
ie storage of various household articles and where wires
un on tops of joists they are very liable to be injured.
should be run on the side of the joists and through bush-
when running crosswise of the joists.

SPECIAL RULES.

Open Work.

dry places.

Must have an *approved* rubber, slow-burning weather-
, or slow-burning insulation.

A slow-burning covering, that is, one that will not carry i is considered good enough where the wires are entirely on insu ing supports. Its main object is to prevent the copper conduct from coming accidentally into contact with each other or s thing else.

h. Must be rigidly supported on non-combustible, n absorptive insulators, which will separate the wires from e other and from the surface wired over in accordance with following table:

Voltage.	Distance from Surface	Distance between Wires.
0 to 300	½ inch	2½ inch
300 to 550	1 inch	4 inch

Rigid supporting requires under ordinary conditions, wh wiring along flat surfaces, supports at least every four one-half feet. If the wires are liable to be disturbed, the tance between supports must be shortened. In buildings mill construction, mains of not less than No. 8 B. & S. g where not liable to be disturbed, may be separated about inches, and run from timber to timber, not breaking aro and may be supported at each timber only.

The neutral of a three-wire system may be placed in center of a three-wire cleat where the difference of pote between the outside wires is not over 300 volts, provided outside wires are separated two and one-half inches.

Must not be "dead-ended" at a rosette socket or recep unless the last support is within twelve inches of the sam

Rubber covered wire is ordinarily used for open worl though slow-burning weatherproof wire or slow-burning may be used. The slow-burning weatherproof wire ha inner coating of weatherproof material of the same char as on outside weatherproof wire. Outside of the coatir placed a coating, fireproof in character, and similar to the ering on the so-called "underwriters" wire. The purpos this covering is to provide an insulation which will protec wires under ordinary circumstances. It is not suitable w moisture is present. The inner coating affords a fairly insulating covering and the outer coating a protection ag fire.

The slow-burning wire has a covering specially designed to thstand heat or fire and is only used in very hot places or ıere a number of wires are bunched. It is also used where ses or fumes are present which would have a tendency to stroy the rubber of the rubber-covered wire.

Figure 106 shows a number of methods of running wires in ıildings of mill construction. At *a* the wires are carried

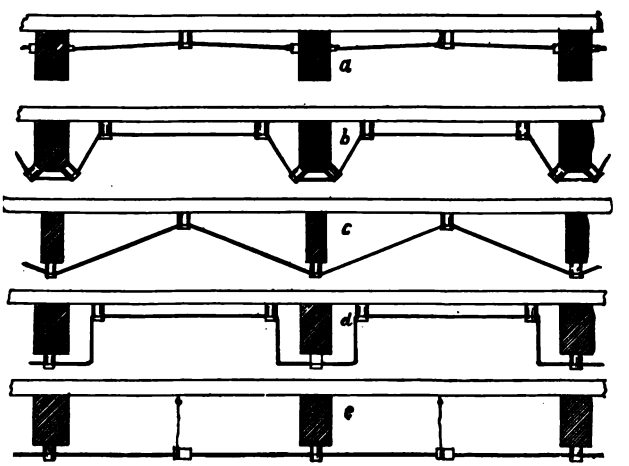


Figure 106.

rough bushings through the beams and supported between ɛams on porcelain insulators. As beams in buildings of mill ɔnstruction are generally quite thick, the installation of bush-gs is expensive and one of the other methods is generally ɛed. The method shown at *b* is very frequently used. If the ɛams are not too thick the wires may be run as shown at *c*. ɪ the wire is large and the ceiling is high so that wires are

not liable to be disturbed they may be run as shown at *d*. With long spans an insulator may be placed on the wire and supported as shown at *e*.

In damp places, or buildings specially subject to moisture or to acid or other fumes liable to injure the wires or their insulation.

i. Must have an *approved* insulating covering.

For protection against water, rubber insulation must be used. For protection against corrosive vapors, either weatherproof or rubber insulation must be used.

j. Must be rigidly supported on non-combustible, non-absorptive insulators, which separate the wire at least one inch from the surface wired over, and must be kept apart at least two and one-half inches for voltages up to 300, and four inches for higher voltages.

Rigid supporting requires under ordinary conditions, where wiring over flat surfaces, supports at least every four and one-half feet. If the wires are liable to be disturbed, the distance between supports must be shortened. In buildings of mill construction, mains of not less than No. 8 B. & S. gage, where not liable to be disturbed, may be separated about six inches, and run from timber to timber, not breaking around, and may be supported at each timber only.

In damp places wires are often run on the under side of an inverted trough as shown in Figure 107. The main point of usefulness of such a trough lies in the fact that it prevents drippings from wetting the wires and insulators. Condensation will, however, keep insulators and wires wet.

The trough to be useful should be put together with many screws or nails, the butting edges of the boards having been first painted with a waterproof paint, with which, when finished, the whole trough is also painted inside and out. If nails are used it will be found that cut iron nails are much less liable to corrosion than the ordinary wire nail. The trough should be made deep enough to protect the wires and should be hung

s low as practicable so as to bring the wires into an even :mperature. This construction will also avoid long drops or >rds.

In connection with wiring in wet places, it is well to re-ember that a stranded wire is much more liable to corrosion ıan a solid wire, for, when exposed, the smaller wires of the :rand provide a greater exposed surface than the equivalent >lid wire. The space between the wires of a strand is very

Figure 107.

able to become full of water due to the capillary attraction of ıe small wires of the strand. With the trough method of >nstruction the drops may be suspended from a split knob.

It is not practical to give exact rules covering electrical >nstruction in all kinds of wet places or in locations exposed > acid fumes as the conditions vary greatly. Constant experi-ıents are being carried on to determine the best class of con-truction for each particular class of service and the Inspection)epartment having jurisdiction should be consulted in each ase before starting any work. It is found at the present time hat in some locations it is necessary to change the wiring very year.

Each insulator when wet allows some current to leak over its surface and, therefore, the fewer we have the better the construction so long as there is no danger of the wires breaking. A form of construction which has given good service where others have failed consists of wires supported on petticoat insulators with the insulators some distance apart. It may be necessary to use a somewhat larger wire than ordinarily but the reduction in the losses from leakage and the trouble from grounds will more than repay the added expense. A modification of this construction consists in running wires on split knobs placed some distance apart with strain insulators at each end of the wire to take care of the strain.

If splices are necessary in wet places they should be made some distance away from the insulators, the insulation at the splice being always weaker than that of the unbroken wire. Care should always be taken that the insulation is not damaged by tying or by clamping under split knobs.

Weather proof sockets are required by the rule. Porcelain weatherproof sockets where exposed to changes in temperature will often crack and fall apart. In such places the moulded composition sockets are better. Brass shell sockets with the butt of the lamp and the entire socket taped and then compounded, while not in accordance with the rule, have proven very durable. In all cases whether the lamp is being used or not it should be left in the socket as it will tend to preserve the inner contacts of the socket.

When clusters are used the supporting stem should be left open at the bottom so that no accumulation of moisture can gather inside the stem. This construction will also allow a circulation of air which will tend to keep the wires inside the stem dry.

For Moulding Work (Wooden and Metal).

(See No. 29. For construction of Mouldings see No. 60.)

k. Must have an *approved* rubber insulating covering, and must be in continuous lengths from outlet to outlet, or from fitting to fitting, no joints or taps to be made in moulding. Where branch taps are necessary in moulding work *approved* fittings for this purpose must be used.

l. Must never be placed in either metal or wooden moulding in concealed or damp places, or where the difference of potential between any two wires in the same moulding is over 300 volts. *Metal* mouldings must not be used for circuits requiring more than 660 watts of energy.

m. Must for alternating current systems if in metal moulding have the two or more wires of a circuit installed in the same moulding.

It is suggested that this be done for direct current systems, also so that they may be changed to alternating systems at any time, induction troubles preventing such a change if the wires are in separate mouldings.

Figure 108 shows the dimensions of approved moulding.

Wires in moulding should always be approved rubber covered. Slow burning weatherproof wire, such as is allowed in

Figure 108.

some classes of open work, should never be used in moulding. For use in metal moulding single braid rubber covered wire is approved.

The rules covering moulding work in previous years allowed joints in the wire within the moulding. This is now forbidden for various reasons among which are the following: It is almost impossible to place a properly insulated joint in moulding as it is generally found necessary to cut away the

the bare wires of the cable. This clamp is mounted on sl
so as to furnish the insulation necessary for the cable.

If a single wire carrying alternating currents of electri
were run in iron pipe there would be a very large drop

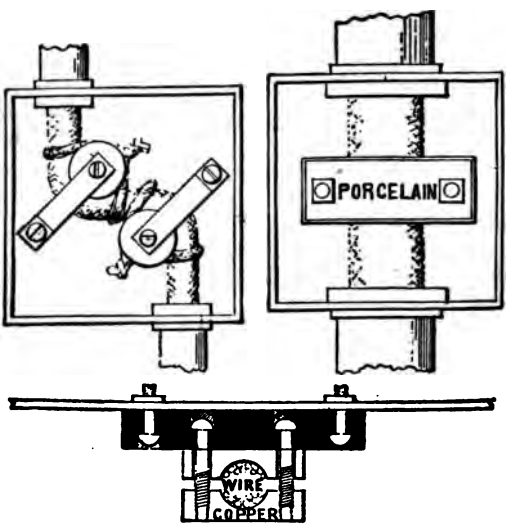


Figure 113.

voltage. This drop is due to the fact that all currents wh
changing in strength generate a counter E. M. F. in their s
roundings. This is particularly strong when the wires are s
rounded by, or very close to, iron. If both wires are run
the same pipe the current in one wire neutralizes that of
other and there is no trouble.

ure 113A and the tabulation given below are designed to in laying out conduit runs where turns are to be made here there are obstructions as in mill-constructed build- In the column at the left are given various radii of bends. lumn 1 is shown the saving in length of conduit effected aking single bends of different radius over what would quired to make square turns.

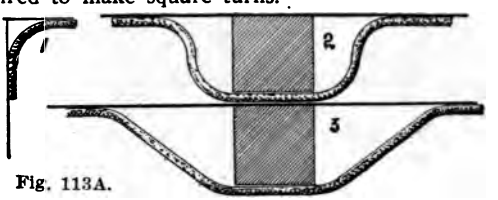


Fig. 113A.

find the actual length of conduit required, measure the ıs though it were made square and subtract the length ches set opposite the corresponding radius of bend. If end is made a true circle the radius will be equal to the ıce from beginning of bend to where the conduit strikes eiling.

ıere it is necessary to run around a beam as shown in ın 2 and the same radius of bend is used there will be bends and the saving will be four times as great as for ngle bend, but it must be borne in mind that a four-inch s, for instance, cannot be used unless the beam is at least inches high.

many cases the run around a beam is made about as in- ed in column 3. The saving effected by this manner nding is approximately given in column 3.

ıdii ends, hes	1 Saving in conduit, inches	2 Saving in conduit, inches	Height of beam, inches	3 Saving in conduit, inches
3	1 1/8	5 1/4	1	1/2
4	1 3/4	7	2	1
5	2 1/8	8 1/2	3	1 1/2
6	2 5/8	10 1/2	4	2
7	3	12	5	2 1/2
8	3 1/8	13 3/4	6	3
9	3 7/8	15 1/2	7	3 1/2
10	4 1/8	17 1/4	8	4
11	4 3/4	19	9	4 1/2
12	5 1/8	20 3/4	10	5
13	5 1/8	22 1/2	11	5 1/2
4	6 1/8	24 1/4	12	6

The following tables show the number of wires of vario sizes which are allowed in conduit. These tables appear in t 1915 edition of the National Electrical Code. In this same e tion the rules governing the construction of rubber-cove wire were changed to allow all wires up to and including 1 B. & S. gauge to have a single-braid covering. This cha in the rule was not taken into account in compiling the ta given in the National Electrical Code and due to the fact the single-braid covering is somewhat smaller than the viously required double-braid covering, many cities are per ting more wires in a conduit than those shown in the ta which appear in the National Electric Code. Tables h therefore, been added showing combination using single-b wires in conduit.

3 Conductor Convertible System

Size of conductors		Size Conduit
3 conductor Size B. & S.	1-conductor Size B. & S.	Electrical tr size
14	10	¾
12	8	¾
10	6	1
8	4	1
6	2	1¼
5	1	1¼
4	0	1½
3	00	1½
2	000	1½
1	0000	2
0	250000	2
00	350000	2½
000	400000	2½
0000	550000	3
250000	600000	3
300000	800000	3
400000	1000000	3½
500000	1250000	4
600000	1500000	4
700000	1750000	4½
800000	2000000	4½

of Conduits for the Installation of Wires and Cables

S.	One conductor in a conduit — Electrical trade size	Two conductors in a conduit — Electrical trade size	Three conductors in a conduit — Electrical trade size	Four conductors in a conduit — Electrical trade size
14	½	½	½	¾
12	½	¾	¾	¾
10	½	¾	¾	1
8	½	1	1	1
6	½	1	1¼	1¼
5	¾	1¼	1¼	1¼
4	¾	1¼	1¼	1½
3	¾	1¼	1¼	1½
2	¾	1¼	1½	1½
1	¾	1½	1½	2
0	1	1½	2	2
00	1	2	2	2½
000	1	2	2	2½
0000	1¼	2	2½	2½
[illegible]				
000	1¼	2	2½	2½
000	1¼	2½	2½	3
000	1¼	2½	2½	3
000	1¼	3	3	3½
000	1½	3	3	3½
000	1½	3	3½	
000	2	3½	3½	
000	2	3½	4	
000	2	3½	4	
000	2	4	4	
000	2½	4½	4½	
000	2½	4½	5	
000	3	5	5	
000	3	5	6	

*Single Conductor, Single Braid, Solid Wires Only

table is not to be used for double braid wires, twin or ires or stranded wires.)

½	½	½	½
½	½	½	¾
½	¾	¾	1
½	¾	¾	1
½	¾	¾	

the joists through hammering in the laying of the floor or in the other work necessary to the completion of the building.

Pipes or other metal work may be placed in contact with the wires either in completing the building or in changes required after the building is completed.

If a fire should for any reason start on the wires the rub-

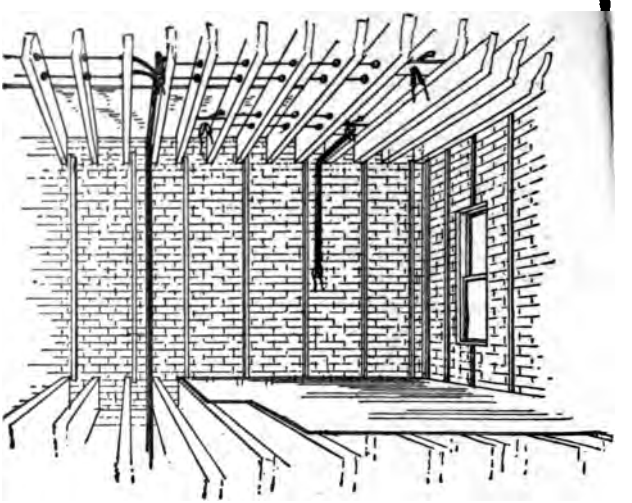


Figure 114.

ber covering is very inflammable and might conduct the fire the combustible woodwork surrounding the wires.

Figure 71 shows the manner in which bushings are plac through the joists. The method shown in the upper part the figure is preferable. In attics the wires must not be r

Concealed "Knob and Tube" Work.

1. Must have an *approved* rubber insulating covering.
2. Must be rigidly supported on non-combustible, non-orptive insulators which separate the wire at least one inch m the surface wired over. Should preferably be run singly separate timbers, or studding, and must be kept at least inches apart.

Must be separated from contact with the walls, floor tim-rs and partitions through which they may pass by non-com-stible, non-absorptive, insulating tubes, such as glass or por-ain. Wires passing through cross timbers in plastered par-ions must be protected by an additional tube extending at ast four inches above the timber.

Rigid supporting requires, under ordinary conditions, where ring along flat surface, supports at least every four and one-lf feet. If the wires are liable to be disturbed the distance ween supports must be shortened.

At distributing centers, outlets or switches where space is ited and the five-inch separation cannot be maintained, each e must be separately encased in a continuous length of ap-ved flexible tubing.

In concealed knob and tube work the wires are supported split knobs on the sides of joists and floor studdings and porcelain tubes where passing through timbers. All wires ist be separated one inch from the surface wired over so t the ordinary porcelain cleats must never be used for this rk.

Concealed knob and tube work was formerly used for all icealed work in frame buildings but many cities are now hibiting its use for the following reasons:

There is a great liability of disturbing the wires after they e been installed.

No matter how careful the wireman may be in placing wires other mechanics on the building are apt to place od beams or other obstructions in contact with the wires er the wireman has left the work as completed.

The porcelain bushings are very liable to be jarred out of

in such a way that it will not catch easily on obstructions, pushes this end into one opening and, by twisting and working backward and forward, gradually forces it toward the other opening. At this opening his helper is stationed with a short wire, also provided with a hook, with which he must seek to catch the other wire when it comes near his opening. When the two wires come in contact, the larger one is drawn out and the conducting wires (encased in approved flexible tubing) are fastened to it and drawn through. The tubing should always be put on the wires before drawing in. If it is put on

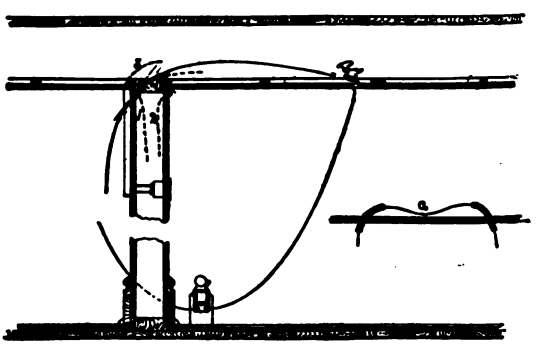


Figure 115.

later there is much temptation to leave it as indicated at the right of the figure at *a*. This trick is quite common, but is very easily detected by inspectors; the wire at either end can easily be pushed in without pushing out at the other, as it would if the tubing were continuous. If the tubing has been taped to the wires this will be impossible, but either one of the tubings can still be moved without moving the other, which would be impossible in a job properly done. The tubing must

consist of one piece, and there must be only one wire in each tubing.

If one man is alone on a fish job, a handful of small wire is pushed into one opening in a manner which will allow it to spread out considerably. When the fish wire from the other opening comes in contact with it, it will indicate it by moving this wire, which can be seen by that left hanging out. A small fish wire is then used to draw out the long one. If the two openings are in different rooms and not visible, one from the other, a bell and battery can be used, as shown in the drawing, if there are no wire lath.

When wires are to be entirely concealed it is nearly always necessary to find a way through headers, timbers, etc.; this can hardly be done without cutting holes in plaster. A method doing as little damage as any is shown at the top in Figure 115. A hole is bored through the 2×4, which will allow the wire, when job is finished, to continue downward as shown by dotted lines, 1 and 2. Such turns are seldom ever used with electric light wires on account of their size; they are more practicable with bell or telephone wires.

Where it is desired to keep wires from showing in a parlor, for instance, they can be fished from an adjoining room, as indicated by dotted line 3, where the wires are run down partition in moulding in closet and then through to switch, which is in the same room with the lights. Before undertaking a job of fish work it is well to look the whole building over carefully. There are often false walls along chimneys, especially at both sides of mantels, in which wires can be easily run from basement to attic.

Often it may be necessary to remove baseboards in order to find room for wires. When removing such boards never attempt to drive nails out, always break them off; if driven out they will usually split off parts of the board.

Soft wood floors can easily be taken up when necessary.

Use a broad thin chisel and cut away the tongue on each side of the board to be taken up; the board can then be readily taken up. With double floors or with tightly laid hardwood floors, it is better to cut pockets in ceiling below.

t. When using either conduit or armored cable in mixed concealed knob and tube work, the requirements for conduit work or armored cable work must be complied with as the case may be.

u. Must at all outlets, except where conduit is used, be protected by *approved* flexible tubing, extending in continuous lengths from the last porcelain support to at least one inch beyond the outlet. In the case of combination fixtures the tubes must extend at least flush with outer end of gas cap.

When the surface at any outlet is broken, it must be repaired so as to leave no holes or open spaces at such outlet.

It is suggested that *approved* outlet boxes or plates be installed at all outlets in concealed "knob and tube" work, the wires to be protected by *approved* flexible tubing, extending in continuous lengths from the last porcelain support into the box.

An installation of mixed concealed knob and tube work is shown in Figure 114. Where it is necessary to use conduit, as is often the case on brick walls, the conduit should extend from outlet to outlet (from the side bracket to the ceiling outlet in Figure 114). If there is no available outlet on the circuit a junction box should be placed at the ceiling line but in all cases this junction box should be accessible. The conduit should never end in the concealed space under the floor for should the wire in the conduit burn out it would be impossible to replace it. The proper method for cases of this kind is shown in Figure 118.

Figure 126 shows in detail the method of bringing wire out at a fixture outlet. The flexible tubing being carried flush with the lower end of the gas cap the wires will be protected when the fixture is put in place. It will be noted that the rule requires the flexible tubing to be continuous. The reason for this is quite evident for, were short pieces used, the wire might

rude at the point of connection and come in contact with gas pipe. Figure 126 also shows the proper method of ening a wire where it comes through a bushing at an out-

In all cases the wires should be fastened under a knob :r passing through the bushing so that they will not slip :k and come in contact with the woodwork.

There are probably more electrical fires started at fixture tlets than at any other point on the system and it is very ;ential that should a fire start at this point it be afforded no :ans for spreading. It will be noticed that when a hole is ade in a ceiling in a frame building a strong draft is nearly ways evident and for this reason care should always be taken see that all openings into the concealed space back of the ister are entirely closed.

r Fixture Work.

v. Must be not smaller than No. 18 B. & S. gage, and must e an approved rubber insulating covering (see No. 55).

In wiring certain designs of show-case fixtures, ceiling ls-eyes and similar appliances in which the wiring is ex-ed to temperatures in excess of 120 degrees Fahrenheit (49 rees Centigrade), from the heat of the lamps, *approved* w-burning wire may be used. All such forms of fixtures st be submitted for examination, test and approval before ig introduced for use.

w. Supply conductors, and especially the splices to fixture es, must be kept clear of the grounded part of gas pipes, , where shell or outlet boxes are used, they must be made iciently large to allow the fulfillment of this requirement.

x. Must, when fixtures are wired outside, be so secured not to be cut or abraded by the pressure of the fastenings motion of the fixture.

y. Wires of different systems must never be contained or ached to the same fixture, and under no circumstances must re be a difference of potential of more than 300 volts be-en wires contained in or attached to the same fixtures.

27. Armored Cables.

(See also No. 26 s. For construction of Armored Cables see No. 57.)

a. Must be continuous from outlet to outlet or to junction boxes, and the armor of the cable must properly enter and be secured to all fittings, and the entire system must be mechanically secured in position.

In case of service connections and main runs, this involves running such armored cable continuously into a main cut-out cabinet or gutter surrounding the panel board, as the case may be.

b. Must be equipped at every outlet with an *approved* outlet box or plate, as required in conduit work.

Outlet plates must not be used where it is practicable to install outlet boxes.

The outlet box or plate shall be so installed that it will be flush with the finished surface, and if this surface is broken it shall be repaired so that it will not show any gaps or open spaces around the edge of the outlet box or plate.

In buildings already constructed where the conditions are such that neither outlet box nor plate can be installed, these appliances may be omitted by special permission of the Inspection Department having jurisdiction, provided the armored cable is firmly and rigidly secured in place.

c. Must have the metal armor of cables permanently and effectually grounded to water piping, gas piping or suitable ground plate, provided that when connections are made to gas piping, they must be on the street side of the meter. If the armored cable system consists of several separate sections, the sections must be bonded to each other, and the system grounded, or each section may be separately grounded, as required above.

The armor of cables and gas pipes must be securely fastened in outlet boxes, junction boxes and cabinets, so as to secure good electrical connection.

If armor of cables and metal of couplings, outlet boxes, junction boxes, cabinets or fittings having protective coating of non-conducting material, such as enamel are used, such coating must be thoroughly removed from threads of both couplings and the armor of cables, and from surfaces of the boxes, cabinets and fittings where the armor of cables or ground clamp is secured in or-

to obtain the requisite good connection. Grounded pipes should cleaned of rust, scale, etc., at place of attachment of ground np.

Connections to grounded pipes and to armor of cables must exposed to view or readily accessible, and must be made by ans of approved ground clamps, to which the ground wires st be soldered.

Ground wires must be of copper, at least No. 10 B. & S. e (where largest wire contained in cable is not greater than o B. & S. gage), and need not be greater than No. 4 B. & gage (where largest wire contained in cable is greater than o B. & S. gage). They shall be protected from mechan- injury.

d. When installed in so-called fireproof buildings in course onstruction or afterwards if exposed to moisture, or where exposed to the weather, or in damp places, such as brewer- stables, etc., the cable must have a lead covering at least thirty-second inch in thickness placed between the outer d of the conductors and the steel armor.

The lead covering is not to be required when the cable is against brick walls or laid in ordinary plaster walls unless e are continuously damp.

e. Where entering junction boxes, and at all other outlets, must be provided with *approved* terminal fittings which protect the insulation of the conductors from abrasion, ess such junction or outlet boxes are specially designed approved for use with the cable.

f. Junction boxes must always be installed in such a man- as to be accessible.

g. For alternating current systems must have the two or e conductors of the circuit enclosed in one metal armor.

h. All bends must be so made that the armor of the cable not be injured. The radius of the curve of the inner edge ny bend not to be less than 1½ inches.

Armored Cable is made up of formed steel strips wound ally over insulated conductors, the conductors themselves ng given a slight twist to make them more flexible. Some nufacturers make the cable with a single strip of steel the er edges of the strips being turned in so that adjacent es interlock, as shown in Figure 116. To make the cable

watertight a gasket is placed between the interlocking edges. This type of cable has the advantage that it is not apt to split open at bends, the interlocking feature preventing this, but it is not very flexible and has the disadvantage that where a sharp bend is required a careless workman is apt to "break" it, this being done by striking it a sharp blow over the edge of

Figure 116.

Figure 117.

a bench and breaking the interlocking edges thus exposing the wire and straining the insulation.

The double strip cable consists of two steel strips, one concave and the other convex. A section of this metal covering is shown in Figure 117. This cable is also made with a gasket to keep out water. It is more flexible than the single strip and is more generally used.

In all types the metal strips are wound on such a diameter as to make it impossible to extract any great length of wire from the sheathing.

Armored cable is very useful for the wiring or rewiring of old buildings and on account of its flexibility it may be installed without any great damage to walls or ceilings. It possesses most of the desirable features of conduit work in so far as safety from fire is concerned. Its greatest objection lies in the fact that it is impossible to replace a burned out wire without replacing the whole cable and for this reason its use is mostly restricted to work in old buildings. If armored cable is "fished" in, and not fastened between outlets, it is always possible to replace any run in which trouble may develop.

In the installation of armored cable the same general rules apply as for the installation of conduit. It must be provided with outlet boxes at all outlets, must be grounded, etc.

Where armored cable is run through holes bored through
ts or is laid in notches cut in same it should be so placed
: nails used in fastening down floors, especially hardwood
rs, will not strike the metal armor, as under these condi-
ıs it is possible for a nail to be driven through the armor
l make contact with the wires. While short circuits and
ıunds due to the cause just mentioned are not very common
expense of taking up floors may be considerable.

Short bends should be avoided in the use of all armored
ıles. When the bend is short there is some strain which
y cause the wire to come into contact with the metal strip
the armor. This will not produce bad effects at once but
ıy do so after a long time. It is well also to test all coils
armored cable for continuity as well as for grounding or
ırt circuits before installing.

Interior Conduits.

ɜe also No. 26 n to p. For construction of Conduit see No. 58, and for construction of Outlet, Junction and Flush Switch Boxes see No. 59.)

The object of a tube or conduit is to facilitate the insertion extraction of the conductors and to protect them from me-nical injury. Tubes or conduits are to be considered rely as raceways, and are not to be relied upon for in-ıtion between wire and wire or between the wire and the ıund.

The installation of wires in conduit not only affords the es protection from mechanical injury, but also reduces the ıility of a short circuit or ground on the wires producing arc, which would set fire to the surrounding material; the duit being generally of sufficient thickness to blow a fuse ore the arc can burn through the metal of the pipe. For ɜ reason the wires should be entirely encased in metal

throughout, both in the conduit and at all outlets. Another advantage derived from the use of iron conduit is the facility with which wires can be extracted and replaced in case a fault develops on any of them. The saving which this may mean in cases where the installation of new wires would necessitate the destruction of costly decorations can readily be seen.

It must be remembered that the arc or burn produced by a short circuit or ground is proportional to the size of the fuse protecting the circuit. If a large fuse, say 30 amperes, is used to protect a branch circuit and a ground or short occurs on this circuit, the wire may become fused to the pipe so that it cannot easily be pulled out. This is one reason why fuses should be as small as practicable. More than six amperes is seldom used on branch circuits, so that no larger fuse than this should ordinarily be used. The installation of wires in iron conduit also reduces the liability of lightning discharges entering a building as the pipe surrounding the wires offers great resistance to the passage of these sudden currents.

Conduit is classed under two general heads, lined and unlined. In both classes of conduit the same thickness of metal is required. Lined conduit is used but little at the present time.

a. No conduit tube having an internal diameter of less than five-eighths of an inch shall be used. Measurements to be taken inside of metal conduits.

This rule favors lined conduit insomuch that it requires the same pipe for lined and unlined, and allows a lined conduit of less than five-eighths of an inch in diameter.

Nominal one-half inch conduit has an internal diameter of five-eighths of an inch.

b. Must be continuous from outlet to outlet or to junction boxes, and the conduit must properly enter, and be secured to all fittings and the entire system must be mechanically secured in position.

se of service connections and main runs, this involves each conduit continuously into a main cut-out cabinet r surrounding the panel board, as the case may be.

n conduit is used every run of pipe must end in acces- tlet boxes. This box may be a cut-out center, switch ixture outlet or a junction box. If a mixed form of is used, where part of a circuit is run in conduit and

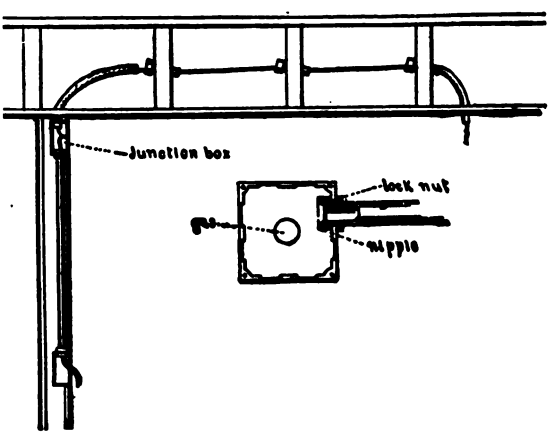


Figure 118.

ınce with some other form of construction, such as :d knob and tube work, for instance, the conduit must :ases enter the box and be firmly attached to it, as n Figure 118. Cases are sometimes found where the is brought just to the box, but does not enter it, the :ing extended through holes into the box. This method ıg, is obviously wrong, as a wireman is apt to find if has oocassion to replace wires in such a system. The

same holds true of cut-out centers. Here also every run of conduit must enter the box. The conduit should not simply be brought to the sides or the back of the cut-out center and the wires then carried to the cut-outs in flexible tubing, but every conduit should enter clear into the box so that when

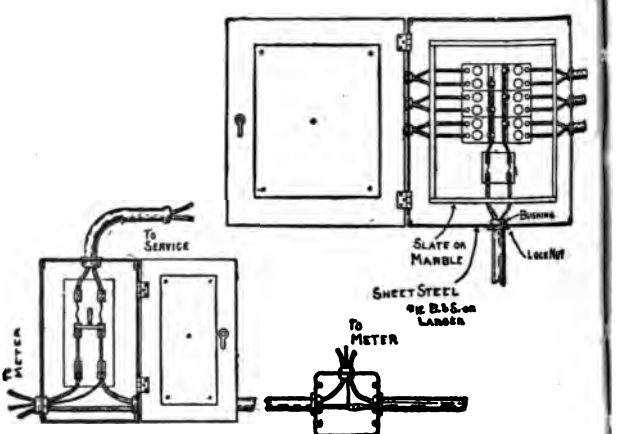


Figure 119.

the work is completed there will be no exposed wiring. In the case of main runs the conduit should enter the boxes and never be broken between the outlets. Sometimes it is necessary to install meters on the mains and the conduit is ended and the wires carried to the meters and then either extended in conduit or carried into the cut-out center. This construction should be avoided. If a meter is to be installed near a cut-out center, the main conduit should be carried into the box and the necessary meter loops then brought out. In this way the quantity of wire outside of conduits is reduced to a min

ı. If a meter is to be installed in some location along the ıs other than at the cut-out center or service switch, a tion box should be provided and the meter loops brought from that. This is shown in Figure 119, which also shows t-out box as used with conduit systems.

Must be first installed as a complete conduit system, out the conductors.

ıs fast as the conduit is installed, the ends of the pipes ıld be closed, using paper or corks. This lessens the liabil- ıf plaster or other substances entering the pipes and caus- trouble when the wires are to be pulled in. The con- ors should not be pulled in until all the mechanical work the building is, as far as possible, finished. When a luit system is ready for the wires, the 'pulling in" may be ; in various ways. For short runs, all that is necessary is hove the wires in at one opening until they come out at other. If a run is too long to be inserted in this way, t is known as a "fish wire" can be used. The ordinary wire is a flat band of steel about 5/32 inch wide and 1/32 thick. This wire can be forced through any ordinary th of pipe. Ordinary round steel wire of about No. 12 4 B. & S. gage can also be used, although this is not as l as the fish wire above described.

The end of the wire is first bent back so as to form a very ll hook or eye; this will enable it to slide easily over ob- ctions in the pipe and also make it possible should it stick ewhere to engage it with another fish wire provided with itable hook and entered from the other end of the pipe. is very often necessary in runs having many bends. The wire, having been pushed through the pipe, is now fastened ıe copper wire by means of a strong hook and the copper pulled into the pipe.

n pulling in the large size cables, it is often found advan- ous to pull on the fish wire and at the same time push on

the end of the cable entering the pipes. It is also well to remember that it is easier to pull down than to pull up, as when pulling down, the weight of the cable assists. The use of soapstone facilitates the drawing in of the wires. The wires may either be covered with the powdered soapstone or the soapstone may be blown into the pipes. An elbow partly filled with soapstone is often found convenient for blowing the soapstone into the pipe, always blowing from the highest point.

Graphite or axle grease should never be used for this purpose, as the graphite is a conductor and the axle grease will rot the rubber insulating covering of the wire.

d. Must be equipped at every outlet with an *approved* outlet box or plate. At exposed ends of conduit (but not at fixture outlets) where wires pass from the conduit system without splice, joint or tap, an approved fitting having separately bushed holes for each conductor is considered the equivalent of a box.

Outlet plates must not be used where it is practicable to install outlet boxes.

The outlet box or plate must be so installed that it will be flush with the finished surface, and if this surface is broken it shall be repaired so that it will not show any gaps or open spaces around the edge of the outlet box or plate.

In buildings already constructed where the conditions are such that neither outlet box nor plate can be installed, these appliances may be omitted by special permission of the Inspection Department having jurisdiction, providing the conduit ends are bushed and secured.

It is suggested that outlet boxes and fittings having conductive coatings be used in order to secure better electrical contact at all points throughout the conduit system.

The object of an outlet box is to hold the conduits firmly in place, to connect the various runs of conduit so that they form a continuous electrical path to the ground, and to afford a fireproof enclosure for the joints, switches, etc. Outlet boxes are made in various designs to meet the requirements of the work on which they are to be used.

Where it is impossible to use an outlet box, an outlet plate
be used. These plates are fitted with clamps so that
y hold the ends of the conduits firmly in position and make
metal of the system continuous. They do not afford a
proof enclosure for the joints and for that reason should
ver be used when it is practicable to use an outlet box. If
conditions are such that neither an outlet box nor plate can
used, special permission can be obtained from the Inspec-
n Department having jurisdiction to omit them. In this
se the conduits should be bushed at the ends and the pipes
ould be bonded together.

This rule requires that an outlet box or plate be used at
ery end of a run of conduit. For the ordinary switch,
ture, and like outlet suitable boxes are available. At ex-
sed ends of conduit special fittings are on the market and

Figure 120.

ould be used. These fittings are especially desirable for the
llowing reasons: They separate the wires where they leave
e conduit and thus tend to destroy any arc which might
sult at the weakest point of the conduit system; the point
ere the wires leave the pipe. They also provide an insu-
ed bushing at that point at which the strain on the insula-
n of the wires is generally the greatest. They also serve
separate the wires in a proper manner, when they leave the
ting. Fittings designed for this purpose are shown in Fig-
e 120.

material, but will take the easiest path to ground, which is along the conduit. On the ordinary branch circuits, the various runs of conduit are bonded together through the outlet boxes and, in connecting the conduits to these boxes, care must be taken that they make good contact. In order to do this, the conduit should enter at right angles to the box and the enamel should be scraped away from the box so that the locknut and bushing make good electrical connection. The same thing should be done where the conduit enters the cut-out box. The metal of the cut-out box will bond together the various branch conduits and the main conduit. The main conduit should now be connected to some good ground, such as a water pipe or metal work of the building. Never carry the ground wire to a gas pipe unless on the street side of a meter. The various branch conduits should also be grounded wherever possible, at and on metal beams over which they cross and at every gas outlet. The reason of grounding the gas pipe thoroughly at the gas outlets is to be sure of a good ground. The gas pipe is necessarily in contact with the outlet box at this point and any poor contact which might cause arcing must be avoided.

The rule specifies a No. 10 wire for grounding conduit where the wire in the conduit system is not larger than No. 0. According to the table of carrying capacities a No. 0 wire will carry 127 amperes and while the No. 10 ground wire may be called upon to carry current sufficient to blow a fuse of this size, the current will last for but a short time and the ground wire will not have time to become dangerously hot.

Special devices for attaching the ground wire to both the conduit and to grounded pipes are on the market and should always be used. Figure 121 shows two forms of ground clamps.

When these are not obtainable a ground connection can be

by taking a number of good turns around the conduit and soldering the wire to the conduit. A better way would use a few T couplings on the system and to screw brass to these and solder the ground wire to the plugs. Such

Figure 121.

plings should be installed near outlets where they will not rfere much with "fishing."

f the ground wire has to be run for any great distance, ıould be installed as though it were at all times alive, and ıld be kept away from inflammable material.

he method advised under 15 for grounding wires should ısed. Where a 3-wire system is used, the best ground ob-

tainable is the neutral wire of the system. When a grou made to the neutral wire, it should be made back of the on the service switch; never make the connection wit neutral inside of the service switch.

g. Junction boxes must always be installed in such a ner as to be accessible.

h. All elbows or bends must be so made that the c or lining of same will not be injured. The radius of the of the inner edge of any elbow not to be less than thr one-half inches. Must have not more than the equival four quarter bends from outlet to outlet, the bends at t lets not being counted.

If more than four quarter bends are necessary, a j box should be installed and the wires first pulled fr of the outlets to the junction box and then from the j box to the other outlet.

Several methods are in use for bending conduit. W lined conduit elbows and bends of various shapes obtained already bent, and it is much more satisfactory these, as considerable care must be exercised in makin in order to keep the inside lining from coming loose f pipe and causing trouble when "pulling in." To prev a suitable spiral spring is sometimes inserted into t duit before bending. Plumbers working with lead pip use coarse sand to fill the pipe before bending. This particularly useful with special conduits such as brass which is sometimes used in showcase or window w classed with fixtures.

With unlined conduits the bending is a simple although here also care must be taken to see that the does not bend flat. In a good bend the pipe retains its form throughout the bend, while, if the bend is poorl the pipe will assume an oval shape, flattening some the bend. The smaller size conduits can be bent in a c

This is best accomplished by gripping the pipe in the nd making a small bend, then moving the pipe for a slight ce and bending again, and continuing until the desired is obtained. This method, however, is not to be rec- nded as, unless the wireman has had much experience on it work and is a very careful workman, the conduit will ore or less flattened at the bends.

nother method which can be used on small pipes is shown in Figure 122, using a three or four foot length of gas or conduit with an ordinary gas pipe T on the end. This

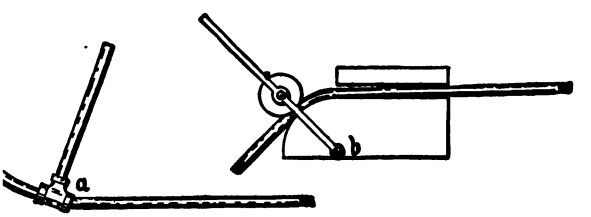


Figure 122.

over the conduit and gives sufficient leverage to make end.

simple device used for bending conduits is shown at *b* gure 122. This is constructed of metal, the wheel being ed to fit the pipe. A similar device minus the wheel ever may be made up of two blocks of wood firmly ed to a work bench. The pipe can be bent around this nd using a piece of pipe large enough to slip over the it to prevent it bending in the wrong place. In lieu of pe just mentioned a tee as shown at *a* Figure 122 may be

r the larger conduits elbows can be obtained already and the use of standard elbows for 90 degree bends in

conduit 1 inch or larger is usually advisable. However, it is often necessary to make bends and offsets in large conduits. In order to bend large conduits some method of holding the conduit in place is necessary. This can often be done in new buildings by placing a heavy timber between the iron beams or columns and placing hard wood blocks on timber to hold the conduit in place.

Connections between the various lengths of conduit are made with the ordinary gas-pipe couplings. When the conduit comes from the factory each length of pipe is provided with a coupling at one end. (This practice is now being discontinued, the couplings being left off.) This coupling should be removed and the end of the conduit reamed out. The reaming

Figure 123.

should always be done so that there is considerable metal left at the end of the pipe, and it should never be carried so far as to leave only a sharp edge. If a thread is to be cut, it is good practice to take a couple of turns with the reamer after this has been done. The coupling can then be screwed on. When making the connection, the pipes should be screwed into the coupling so that the ends just "butt." Do not attempt to screw them too tight, or, in all probability, the thread on the end of the pipe will be turned in and close the opening. Figure 123, *a*, shows how a connection should be made. If lined conduit is not properly reamed and is screwed too tight the opening is often entirely closed or forced downward, as shown at *b*.

It is often necessary, especially in making changes in old

installations, to fit pieces between two pipes, neither one of which can be turned so as to draw them together. In such cases a long thread is cut on one piece of the pipe and the coupling run back on it; when the pipes are butted together the coupling is run over the two pipes, thus connecting them. A locknut may be run upon either pipe and used to keep the coupling in place.

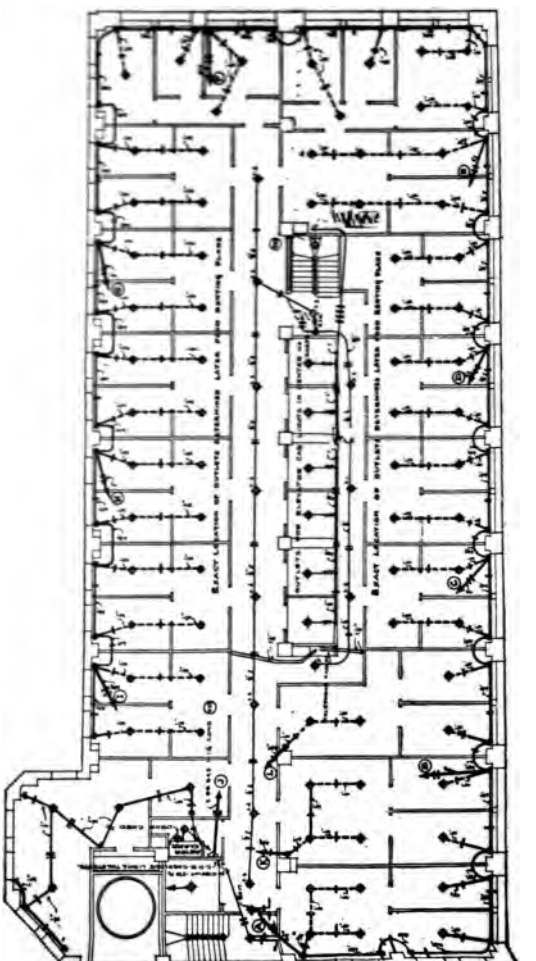
In running conduits avoid as much as possible passing through bath-rooms and other places where plumbers are likely to run their piping.

When practicable, conduits should be run so they will drain; for instance, where crossing a room from one side bracket to another, it is better to run along ceiling than along the floor. Conduits will sometimes become quite moist inside from condensation. Where there is any likelihood of this the ends may be sealed.

Figure 124 shows the wiring plan of a modern office building. It will be seen from a close examination of the plan that there are several novel features in the layout of the circuits. The particular building to which this plan refers is designed for use as separate small offices or shops or the whole floor may be arranged for one tenant.

In buildings of this class the final location of the outlets on the various floors is a subject of much uncertainty until the particular floor is rented and this may not be until after the rough work on the building is entirely completed. The usual method of placing conduit pipes together with switch and bracket outlets in partition walls necessitates either the altering of considerable conduit work to conform to the renting plans, or that only a small proportion of the conduit can be put in place when the first portion of the work is done.

With the layout shown by the floor plan no outlets or conduits are placed in any partitions. All circuits are carried to the outside walls of the building which, of course, are never altered. The conduits from the cutout center on each floor are large enough to carry additional circuits for future use and terminates in a 3-gang box. From this box conduits



Figur

Before the plastering is put on, a board should be fastened between the joists, so that the wooden block may later be screwed to it. This is not absolutely necessary, as screws in lath will usually hold light fixtures. Heavy fixtures in old buildings can best be hung as shown at *b*, in Figure 127. This method is also used for ceiling fan motors. These motors must never be rigidly fastened, but should always be left free to swing and find their own centers.

In connection with open or moulding work, the canopies should always be cut out, so that the loom or moulding may

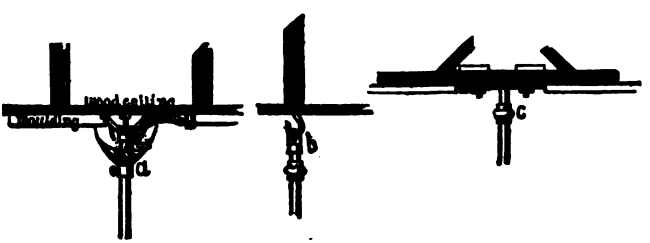


Figure 127.

enter them. On no account should wires be allowed to rest on sharp edge of canopy. See *a*, Figure 127.

Figure 127 illustrates at *c* how fixtures are fastened to tile ceilings, toggle bolts and a metal strip to which a piece of pipe is fastened being used.

The "construction rules" covering insulating joints require that the joint be capable of withstanding a voltage test of 4,000 volts. It is, of course, just as important that the canopies of fixtures be insulated from the walls or ceilings by an insulator capable of withstanding a like voltage test. Figure 128 shows a very acceptable type of canopy insulator, known as the "Bechtold" insulator. It is provided with a

modified to require the protecting piping from the ceiling below to a point at least three inches above the flooring.

c. Backing must be secured in position by screws or bolts, the heads of which must be flush with the metal.

d. Must have the metal of moulding permanently and effectually grounded to water piping, gas piping, or suitable ground plate, provided that when connections are made to gas piping, they must be on the street side of the meter. If the metal moulding system consists of several separate sections, the sections must be bonded to each other and the system grounded, or each section may be separately grounded, as required above.

Metal mouldings and gas pipes must be securely fastened to outlet boxes, junction boxes and cabinets, so as to secure a good electrical connection. Moulding must be so installed that adjacent lengths of moulding will be mechanically and electrically secured at all points.

If metal moulding, couplings, outlet boxes, junction boxes, cabinets or fittings have protective coating of non-conducting material such as enamel are used, such coating must be thoroughly removed from threads of couplings and metal mouldings, and from the surfaces of boxes, cabinets and fittings, where the metal moulding or ground clamp is secured in order to obtain the requisite good connection. Grounded pipes should be cleaned of rust, scale, etc., at the place of attachment of the ground clamp.

Connection to grounded pipes and to metal mouldings must be exposed to view, or readily accessible, and must be made by means of approved ground clamps, to which the wires must be soldered.

Ground wires must be of copper, at least No. 10 B. & S. gage. They shall be protected from mechanical injury.

e. Must be installed so that for alternating systems the two or more wires of a circuit will be in the same metal moulding

It is suggested that this be done for direct systems also, so that they may be changed to the alternating system at any time, induction troubles preventing such change if the wires are in separate mouldings.

Metal moulding is a comparatively recent development in wiring methods. It does away with a number of the objectionable features that exist in the case of wood moulding very closely resembling conduit in point of safety from fire. At the same time it retains most of the useful features of wood

ding. Its use is bound to become more extensive as cities are now prohibiting the use of wood moulding en-

consists of a backing and a capping, both of metal, the ng being first fastened in place and the wires then laid in covered by the capping. Figure 183 shows one form of l moulding with some of the fittings.

he rules governing its installation are very similar to governing the installation of conduit and the explana- made under the head of conduit will apply equally here.

he thickness of metal not being as heavy as required for uit it is more liable to mechanical injury and must fore be protected on side walls. For the same reason se is limited to circuits of not more than 660 watts Rule 26*l*), and not larger than 6 ampere fuses should be used for the circuit protection.

Fixtures.

also Nos. 24 e, 26 v to y and 55. For construction of Fixtures see No. 77.)

When supported at outlets in metal conduit, armored , or metal moulding systems, or from gas piping or any ided metal work, or when installed on metal walls or gs, or on plaster walls or ceilings containing metal lath, n walls or ceilings, in fireproof buildings, must be in- ed from such supports by approved insulating joints d as close as possible to the ceilings or walls. The ating joint may be omitted in conduit, armored cable or moulding systems with straight electric fixtures in n the insulation of conductors is the equivalent of insula- in other parts of the system, and provided that approved ts, receptacles or wireless clusters are used of a type g porcelain or equivalent insulation between live metal and outer metal shells, if any.

as pipes must be protected above the insulating joint by ved insulating tubing, and where outlet tubes are used

two fixture wires are connected to one wire of the magneto and the other wire is connected to the metal of the fixture.

It is best to connect this wire to the iron piping, and not to the lacquered brass; the lacquer is often a very good insulator. If a ring is now obtained, it indicates that the insulation on a wire has been damaged, and that the bare wire is in contact with the fixture. This test can be made more thorough by working the accessible fixture wires back and forth during the test; sometimes a damaged portion of wire is not in contact with the metal of fixture while lying upon the floor, but may be brought in contact with it when hanging.

Fixtures that have been connected to the circuit and provided with insulating joints can be individually tested for "grounds," by connecting one wire of a magneto to the body of the fixture and the other, first to one, and then the other, of the circuit wires in the sockets. This test will detect a "ground" in a fixture without disconnecting it from the circuit.

A battery and bell or, better still, an incandescent light in series on a lighting circuit may be used for the testing in place of the magneto. A telephone receiver and a small dry battery such as is used in pocket flash lamps forms a compact and very useful testing device. This may be carried without inconvenience in the pocket and is available for testing at any time.

In connecting sockets to fixtures, it is advisable to connect them so that all protruding parts, as keys or receptacles for lamps, be of the same polarity, that is, all connected to the same main wire. This also applies to reflectors, border lights for theaters, encased in metal, etc. This will not lessen the liability of such parts to "ground," but lessens the chances of short circuits very much. Many "shorts" are brought

t by the projecting brass lamp butts on fixtures being pposite polarity. If they are of the same polarity, they cause no trouble.

pecial fixtures for show windows, etc, are often made up hown in Figure 129. The construction shown at the is more compart and neat, but requires more care in lling than the other, because of the edges of pipe in

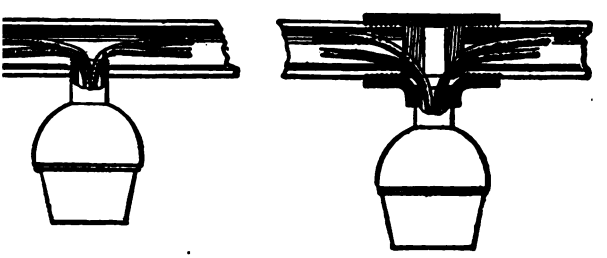


Figure 129.

act with the wires. If very long fixtures of this kind are alled, it is advisable to insert insulating joints as often racticable, even if necessary to run wires around them.

Sockets.

(For construction rules, see No. 72.)

. In rooms where inflammable gases may exist the in-lescent lamp and socket must be enclosed in a vapor-tight e, and supported on a pipe-hanger, wired with *approved* er-covered wire soldered directly to the circuit.

Key sockets contain a switch (see No. 17 *b*).

Figure 130, shows "vapor-tight" globes and Figure *a* the method of suspending on a pipe hanger, the construc-

tion of which complies with the requirements of this n If moisture is present it is well to seal the upper end of pipe with compound.

Key sockets must not be used in rooms where infl mable gases exist. If enclosed as required above they w be useless.

The reason for requiring vapor proof sockets to be ported on pipe hangers is that they will be rigid and ca

Figure 130.

be moved about sufficiently to come in contact with ar ject which might cause them to be broken. They s therefore be hung as high as circumstances will perr that they will not be broken by being struck by anythin ried through the room.

b. In damp or wet places "waterproof" sockets m used. Unless made up on fixtures they must be hung b arate *stranded* rubber-covered wires not smaller than 1 B. & S. gage, which should preferably be twisted to when the pendant is over three feet long.

These wires must be soldered direct to the circuit but supported independently of them.

c. Key sockets will not be approved if installed ov cially inflammable stuff, or where exposed to flyings o bustible material.

roof sockets are constructed of porcelain, mica or ıbber as shown in Figure 132, and are not provided therefore the circuits to which they are connected ntrolled by switches. As a general rule these sock- ırnished with a short piece of stranded, rubber- ire extending through sealed holes in the top of and the supporting wires are soldered to them. The

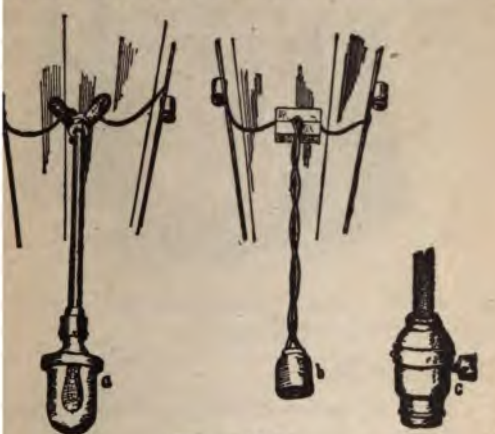


Figure 131.

suspending waterproof sockets varies with the con- Ordinarily, stranded rubber-covered wires of the gth are suspended from single cleats as shown at re 131, or, if the split knobs are large enough, the vire may be supported from them. If the lamp is ended only a short distance from the ceiling, where be liable to be disturbed, it may be hung from two nch porcelain knobs, as shown in Figure 107. If used in a damp place for supporting the drop a half

cleat must be provided back of the supporting cleat to give a one-inch separation, as required for wires in wet places.

Moulded rubber sockets should not be used where oils or greases are present as these have a deleterious effect on the composition of which the socket is made. In some locations

Figure 132.

tions porcelain sockets in which sulphur is used will break from the expansion of the sulphur.

32. Flexible Cord.

(For Construction of Flexible Cord see No. 54.)

a. Must have an *approved* insulation and covering.

b. Must not, except in street railway property, be used where the difference of potential between the two wires is over 300 volts.

c. Must not be used as a support for clusters.

d. Must not be used except for pendants, wiring of fixtures, portable lamps or motors, and portable heating apparatus.

For all portable work, including those pendants which are liable to be moved about sufficiently to come in contact with surrounding objects, flexible wires and cables especially designed to withstand this severe service must be used.

When necessary to prevent portable lamps from coming

ntact with inflammable materials, or to protect them breakage, they must be surrounded with a substan- ire guard.

nder the heading of flexible cord are all the various of fiexible wires such as, common pendant cord, port- cord, stage cable, etc., and the construction rules, No. ıould be very carefully read.

he practice of making pendant cords unnecessarily long :hen looping them up with cord adjusters is strongly ad- against. It offers a temptation to carry about lamps ı are intended to hang freely in air. These adjusters ld never be used where their use can be avoided and e they are used should only be placed on lamps which

Figure 133.

seldom need adjusting. The indiscriminate use of cord sters cannot be too strongly condemned as the constant ing of the adjuster soon destroys the insulation.

c, Figure 131, shows a brass socket threaded for ⅜- pipe, and which is designed to be used with portable

Care should be taken in making up these sockets to hat the knot under the head of the socket has a good ng surface so that it will not pull through the larger ing, these portables being very apt to be jerked about.

lamp guard to be of any value should be so constructed the bulb of the lamp cannot come in contact with any- outside of the lamp guard; it should also protect the from any sudden jar. The design of the guard should ch that it can be firmly attached to the socket so it will

rent for branch conductors, it would be well to provide this also for mains in such cases where groups of arc lamps are likely to be controlled by one switch and used together.

Figure 134 at the right shows a diagram of wiring for flaming arc lamps. Two lamps are usually run in series on 110 volts together with a steadying resistance.

b. Must only be furnished with such resistance or regulators as are enclosed in non-combustible material, such resistances being treated as sources of heat. Incandescent lamps must not be used for this purpose.

c. Must be supplied with globes and protected by spark arresters and wire netting around the globe, as in the case of series arc lamps (see No. 21).

Outside arc lamps must be suspended at least eight feet above sidewalks. Inside arc lamps must be placed out of reach or suitably protected.

d. Lamps when arranged to be raised and lowered, either for carboning or other purposes, shall be connected up with stranded conductors from the last point of support to the lamp, when such conductor is larger than No. 14 B. & S. gage.

This is required as a solid wire is apt to break from the constant swinging of the wires from the wind and from the raising and lowering of the lamp.

34. Mercury Vapor Lamps.

Enclosed Mercury Vapor Lamps.

a. Must have cut-out for each lamp or series of lamps except when contained in single frame and lighted by a single operation, in which case not more than five lamps should be dependent upon single cut-out.

b. Must only be furnished with such resistances or regulators as are enclosed in non-combustible cases, such resistances to be treated as sources of heat. In locations where these resistances or regulators are subject to flyings of lint or combustible material, all openings through cases must be protected by fine wire gauze.

The Cooper-Hewitt mercury vapor lamp is shown diagramatically in Figure 135. It consists of a long glass tube at one extremity of which is a metal reservoir partially filled with mercury. The lamp may be started by tilting the tube to a horizontal direction when the mercury flows out of the reservoir and forms a metallic stream connecting electrically the two terminals at each end of the lamp. As soon as the circuit is established the lamp is released and the mercury flows back into the reservoir but the current continues to flow through a path afforded by the mercury vapor. A greenish light is produced.

So far as the installation rules are concerned, this lamp is similar to the arc lamp. A resistance is always provided

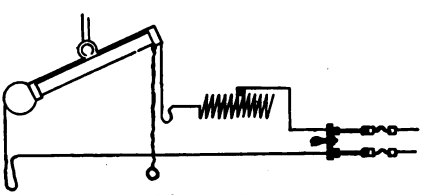


Figure 135.

to hold down the starting current when the lamp is short circuited by the stream of mercury and also to adjust the lamp to the proper current. Lamps are run either singly or two in series on 110 volts or four in series on 220 volts, and for photographic work they are mounted in a frame, but in accordance with the rule, more than five lamps must never be dependent on one cut-out.

High-Potential Vacuum Tube Systems.

c. The tube must be so installed as to be free from mechanical injury or liability to contact with inflammable material.

d. High-potential coils and regulating apparatus must be installed in approved steel cabinet not less than one-tenth inch in thickness; same to be well ventilated in such a manner as to prevent the escape of any flame or sparks, in case of burnout in the various coils. All apparatus in this box must be mounted on slate base and the enclosing case positively grounded. Supplying conductors leading into this high-potential case to be installed in accordance with the standard requirements governing low-potential systems, where such wires do not carry a potential of over 300 volts.

The Moore tube is the best known vacuum tube lighting system. This system of lighting has not come into any general use as it is still in a more or less experimental stage. It consists of a long gas tight tube carried around the space to be lighted. This tube is filled with a gas and the kind of gas used determines the character of the light. A high potential produced by specially designed transformers causes the current to flow through the gas in the tube.

35. Economy Coils.

a. Economy and compensator coils for arc lamps must be mounted on non-combustible, non-absorptive, insulating supports, such as glass or porcelain, allowing an air space of at least one inch between frame and support, and must in general be treated as sources of heat.

Economy or compensator coils are used in connection with arc lamps on multiple alternating current circuits. They serve the same purpose that the resistance coil does on the direct current arc lamp, but unlike the resistance they operate without the development of any great amount of heat. Some heat is, however, produced and these coils must be mounted away from woodwork or other combustible material.

36. Transformers.

(See also Nos. 11, 14, 15 and 45. For construction of Transformers see No. 81.)

Oil transformers:—

a. Must not be placed inside of any building except central stations and sub-stations, unless by special permission of the inspection department having jurisdiction.

Air cooled transformers:—

The following sections do not apply to apparatus or fittings, the operation of which depends either wholly or in part upon special transformers embodied in the devices, but all such apparatus or fittings must be submitted for special examination and approved before being used.

b. Must not be placed inside of any building excepting central stations and sub-stations, if the highest voltage of either primary or secondary exceeds 550 volts.

c. Must be so mounted that the case shall be at a distance of at least one foot from combustible material or separated therefrom by non-combustible, non-absorptive, insulating material, such as slate, marble or soapstone. This will require the use of a slab or panel somewhat larger than the transformer.

Oil cooled transformers are objectionable when installed inside of a building because the transformer has within it all that is necessary to both start a fire and to spread it after once started. For this reason the rule forbids them inside of the ordinary building. There are special conditions however, where oil cooled transformers must be used and in such cases the inspection department having jurisdiction must be consulted before installation.

37. Decorative Lighting Systems.

a. Special permission may be given in writing by the Inspection Department having jurisdiction for the temporary installation of *approved* Systems of Decorative Lighting, pro-

vided the difference of potential between the wires of any circuit shall not be over 150 volts and also provided that no group of lamps requiring more than 1,320 watts shall be dependent on one cut-out.

The Elblight decorative lighting system is approved for temporary installations. This system consists of a pair of heavy copper wires made up with fine copper strands. The wires are insulated and covered with an unsaturated braid. Receptacles for use with these wires are of porcelain, the terminals being two pointed pins which are stuck into the wire through the insulation, the pins entering the fine strands and making contact. The receptacles are held to the wire by porcelain pieces which clamp around the two wires. Receptacles may be attached to the wire at any point but in no case must more than 1320 watts be dependent on one cut-out.

Other decorative lighting systems are limited mostly to Christmas tree lights. There are a great number of these on the market and some of them are dangerous and should not be used. The list of approved fittings issued by the Underwriters laboratories should be consulted to determine those safe to use.

38. Theatre and Moving Picture Establishment Wiring.

All wiring, apparatus, etc., not specially covered by special rules herein given, must conform to the standard rules and requirements of the National Electrical Code, and the term "theatre" shall mean a building, or that part of a building regularly or frequently used for dramatic, operatic, moving picture or other performances or shows or which has a stage for such performances used with scenery or other stage appliances.

a. Services.

Where supply may be obtained from two separate street mains, two separate and distinct services must be installed, one service to be of sufficient capacity to supply current for the entire equipment of theatre, while the other service must

be at least of sufficient capacity to supply current for all emergency lights. Where supply cannot be obtained from two separate sources, the feed for emergency lights must be taken from a point on the street side of main service fuses. By "emergency lights" are meant exit lights and all lights in lobbies, stairways, corridors, and other portions of theatre to which the public have access, which are normally kept lighted during the performance.

Where source of supply is an isolated plant within same building, an auxiliary service of at least sufficient capacity to supply all emergency lights must be installed from some outside source, or a suitable storage battery within the premises may be considered the equivalent of such service.

The spirit of this rule requires that the 'emergency" lighting system be kept entirely separate and distinct from the general lighting system. The emergency lighting system is designed to provide illumination sufficient for the audience to get from the auditorium to the outside of the building under any and all conditions liable to exist, even where the general illuminating system has been rendered useless. It is, therefore, of the utmost importance that the emergency system be made as reliable as is possible to the end that under no condition liable to exist will these lights be out of service. Figure 136 shows how this rule and also e-4 may be complied with. The emergency circuit should if possible be taken from mains that have no connection whatever with those supplying the auditorium and stage lights. The emergency mains must lead to the lobby and are not allowed to have any fuses except those at the street and those finally protecting the branch circuits. Under certain interpretation of this rule it is permissible to connect the two systems as shown by dotted lines. This is, however, bad practice, as the switch may be unintentionally left as shown in the cut and thus when the main fuse blows all of the lights will be out. In many cases this arrangement will be very costly, as often lobby and theater mains do not run close together. As

them and thus cause troubles of many kinds. One of the principal preventive devices is a lamp guard fastened to each socket in such a way that it cannot be removed without assistance from the house electrician. This will prevent the removal of the lamp and the substitution of a lamp of greater candle power or of the portable devices which many actors carry that require much more current. A lamp guard so arranged that it can be locked on will readily accomplish the purpose and such lamp guards are on the market.

The principal use of light in the dressing rooms is for the "make-up" of the actors. One light on each side of every mirror, suitably placed, with one or two lights for general illumination, are generally sufficient. A receptacle for curling iron connection can also be provided, but should also be under lock and key.

Dressing room circuits should be very lightly fused so that the use of electric irons will surely blow fuse.

k. Portable Equipment.

Arc lamps used for stage effects must conform to the following requirements:—

1. Must be constructed entirely of metal except where the use of approved insulating material is necessary.
2. Must be substantially constructed, and so designed as to provide for proper ventilation, and to prevent sparks being emitted from lamps when same are in operation, and mica must be used for frame insulation.
3. Front opening must be provided with a self-closing hinged door frame, in which wire gauze or glass must be inserted, except in the case of lens lamps, where the front may be stationary, and a solid door be provided on back or side.
4. Must be so constructed that neither carbons nor live parts will be brought into contact with metal of hood during operation, and arc lamp frames and standards must be so installed and protected as to prevent the liability of their being grounded.

5. Switch on standard must be so constructed that accidental contact with any live portion of same will be impossible.

Figure 149.

Figure 150.

6. All stranded connections in lamp and at switch and rheostat must be provided with approved lugs.

7. Rheostats must be plainly marked with their rated capacity in volts and amperes, and, if mounted on standard,

The switchboard of necessity being close to the stage proper is generally in such a position that persons leaving the stage pass directly in front of it. As the costumes worn by actors are very often made up of tinsel or other conduct-

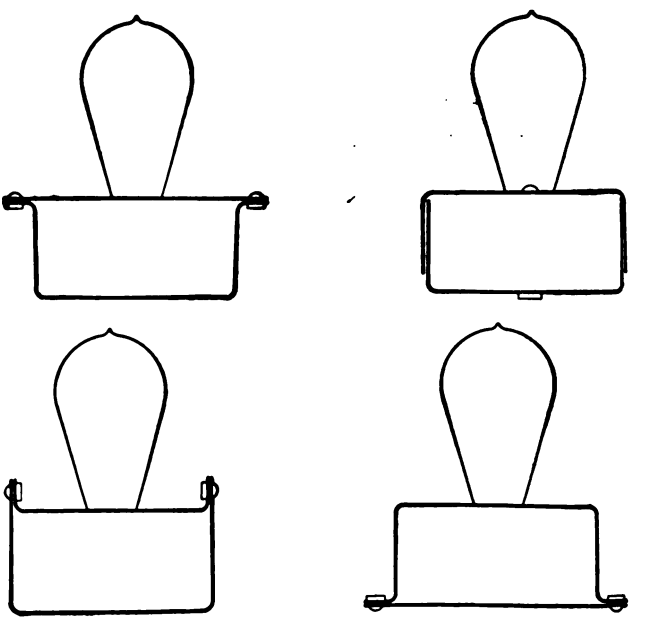


Figure 138.

ing material, and as various metal trappings are carried, it is essential that the guard rail be of such design as to prevent these materials from coming in contact with the live parts of the board. Where the guard rail is placed close to

the board it is often advisable to provide a screen between the guard rail and the floor.

The best method, however, so far as safety is concerned is that of elevating the switchboard so that there can be no interference with it.

l. Footlights.

Must be wired in approved conduit or armored cable, each amp receptacle being enclosed within an approved outlet box, or the lamp receptacles may be mounted in an iron or steel box, metal to be of a thickness not less than No. 20 U. S. Sheet Metal gage treated to prevent oxidation, so constructed as to enclose all the wires. Wires to be soldered to lugs of receptacles.

Must be so wired that no set of lamps requiring more than 1,320 watts nor more than 24 receptacles shall be dependent upon one cut-out.

Figure 138 shows a number of forms in which footlight troughs are made up. These troughs are constructed of No.

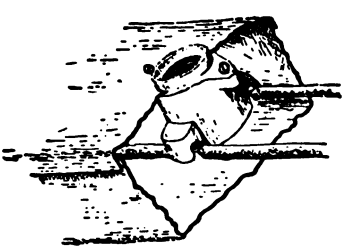


Figure 139.

20 U. S. sheet metal gage iron or steel, the receptacles being attached to the upper section as shown in Figure 139. The completed footlight strip is shown in Figure 140. These strips are combined in various ways to make up the foot-

light proper, their arrangement depending on the lighting effect desired. A common arrangement is shown in Figure 141, where two separate strips are used, one elevated above the other in order that the light from the back row of lamps will not be obstructed by the lamps in the front row. When

Figure 140.

footlights are installed in this manner more light is obtained when the clear lamps are placed in the front row, as only a small part of the light emitted from the colored lamps will be absorbed by passing through the clear globes, while, with the reverse arrangement, where the colored lamps are placed

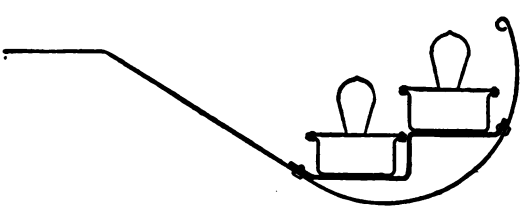


Figure 141.

in the front row, a considerable amount of light would be absorbed by the light from the clear lamps passing through the colored glass. Owing to the fact that the footlights are generally placed in troughs cut in the stage floor, thus bringing the lamps below the level of the stage floor, the placing of the white lamps in the lower row would not allow sufficient

of receptacles, and approved lugs must be provided for connection of the master cable.

When a number of pieces of electrical apparatus are to be d at one time on the stage, instead of carring a separate

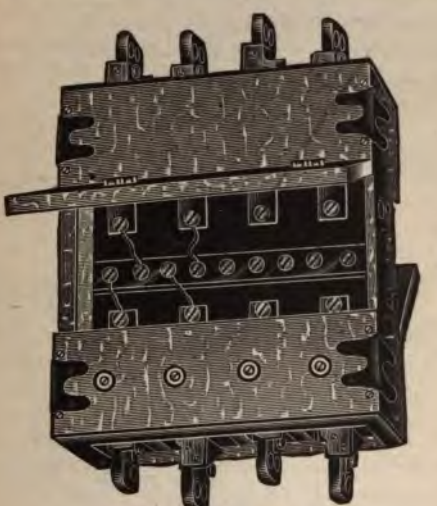


Figure 152.

le from each piece of apparatus to a pocket, a portable gging box or "spider box" is used. This is shown in Fig- 152. One large cable is carried from the plugging box to ocket or other convenient point of connection and the ious pieces of apparatus connected to the plugging box by gs and short cables. This greatly reduces the amount of le used and allows of rapid assembly and removal.

watts, this allowing 24-16 c. p. lamps, 18-24 c. p. lamps, or 12-32 c. p. lamps of the carbon filament type on one circuit.

e. Borders and Proscenium Sidelights.

1. Must be constructed of steel of a thickness not less than No. 20 U. S. Sheet Metal gage, treated to prevent oxidation, be suitably stayed and supported, and so designed that flanges of reflectors will protect lamps.

2. Must be so wired that no set of lamps requiring more than 1,320 watts nor more than 24 receptacles shall be dependent upon one cut-out.

3. Must be wired in approved conduit or armored cable, each lamp receptacle to be enclosed within an approved outlet box, or the lamp receptacles may be mounted in an iron or steel box, metal to be of a thickness not less than No. 20 U. S. Sheet Metal gage treated to prevent oxidation, so constructed as to enclose all wires. Wires to be soldered to lugs of receptacles.

4. Must be provided with suitable guards to prevent scenery or other combustible material coming in contact with lamps.

5. Cables for borders must be of approved type and suitably supported; conduit construction must be used from switchboard to point where cables must be flexible to permit of the raising and lowering of border.

6. For the wiring of the border proper, wire with approved slow-burning insulation must be used.

7. Borders must be suitably suspended, and if a wire rope is used same must be insulated by at least one strain insulator inserted at the border.

The design and construction of border lights is similar to that just described for footlights with the exception of the arrangement of the strips and the kind of wire used. Border lights are suspended above the stage and are designed to throw the light downward and slightly to the back of the stage. To produce the proper lighting effects the border must be capable of adjustment, both as to its height above the stage and its position.

Figure 143 shows several forms of border lights.

Figure 144 shows a simple form of border light in common use. It will be noticed that the flange of the reflector is

Figure 143.

carried around the lamps in such a manner as to protect them from accidental contact with the scenery.

Figure 145 shows a completed border light with one method of suspension. The iron bands to which are fastened the supporting chains are carried entirely around the border frame and serve as a means of attaching it to its support and at the same time provide mechanical protection

Figure 144.

for the lamps. These bands are placed from four to six feet apart.

The cables which carry current to the border lights are generally made up for each individual installation, the size and number of wires varying according to the number and

combination of lamps used and the distance of the border from the stage switchboard or center of distribution.

See 54f for specifications governing border cables.

The cables should be long enough to allow the border to be lowered to within six or seven feet of the floor to permit of the necessary repairs and adjustments and the replacement of lamps.

"Take-up" devices, which are attached to the cable to take up the slack when the border is raised, should be fastened to the cable by some suitable device which will give a large

Figure 145.

bearing surface so that the insulation of the cable will not be injured. The practice of simply tying a rope around the cable is very bad, as the rope is sure to cut into the insulation.

As considerable heat is developed in a border light, due to the great number of lamps employed and to the position of the border itself, the rubber covering of the ordinary rubber covered wire would be very apt to become useless as an insulator, so that for this class of wiring slow-burning wire should be used. Specifications covering this wire are given under "Fittings."

running the exit light main direct to the service, not changing size and not tapping onto any other main unless both mains are of equal carrying capacity.

All sockets used on the exit and emergency lighting should

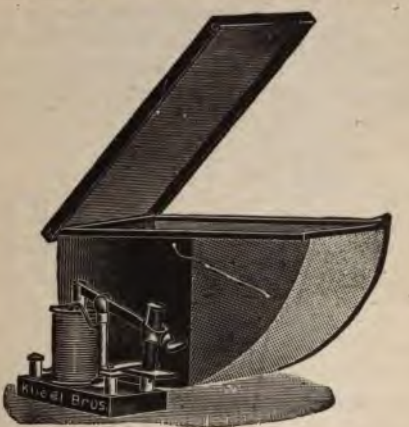


Figure 155.

be of the keyless type, so that they cannot be controlled from any point except the lobby.

u. Moving Picture Equipments.

1. *Arc Lamp Used as a Part of a Moving Picture Machine.*—Must be constructed. so far as practicable, similar to arc lamps of theatres, and wiring to same must not be of less capacity than No. 6 B. & S. gage.

In the typical moving picture house it is customary, where three wire service exists, to balance the arc lamp used for the picture machine against the incandescent lights used in house about as illustrated in Figure 156. It is a wise precau-

tion to make connections to the arc as shown in the figure, placing the rheostat between the arc and the neutral wire. If this precaution is observed the operator will not be so likely to receive a shock when working on rheostat while it is alive. There will also be less liability of short circuits or trouble on the wiring between arc lamp and rheostat of which there is usually considerable. The asbestos wire entering arc lamp is likely to burn off at arc terminal perhaps, once per week and

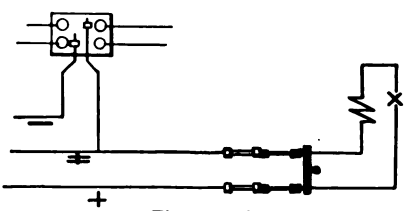


Figure 156.

operators are prone to carry as much slack on this as they dare.

2. *Rheostats.*—Must conform to rheostat requirements for theatre arcs.

3. *Top and Bottom Reels.*—Must be enclosed in steel boxes or magazines, each with an opening of approved construction at bottom or top, so arranged as not to permit entrance of flame to magazine. No solder is to be used in the construction of these magazines. The front side of each magazine must consist of a door spring-hinged and swinging horizontally, and be provided with a substantial latch.

The opening referred to that will not permit entrance of flame to magazine consists generally of two or more small rollers between which the film moves. These fit quite closely together and if well made and adjusted will not permit any fire to get by. Some of these as an additional precaution (which

is much to be recommended) have in addition to the rollers a narrow tube of about 1½ inches in length through which the film is drawn. It has by repeated experiments been found impossible to draw a flaming piece of film through this aperture.

The two provisions of the rule concerning the door to the magazine do not seem to be of the wisest. Close observation of numerous operators at work reveals the fact that they are nearly all given to opening their magazines a little while before finishing a picture so as to be ready for a quick change of film. When the change of film is made they have the habit of resuming the run without stopping to close the doors at once and afterward forgetting about it. A spring hinge on door would naturally close it but the spring pressing against door is very annoying while changing film and threading and is therefore often found blocked. The net result of a spring hinge is often that the door is permanently blocked open. To avoid the unnecessary dangers careless operators subject their audiences to, in this way, magazines have been devised in which it is difficult or entirely impossible for a film to be run off unless the doors are securely locked.

If such magazines are not to be insisted upon it would seem preferable to hinge the door on the side at which the fire valves (as the rollers through which the film must pass are called) are located. A door arranged in this way and tightly fitting against the hinge side of the magazine may prevent flames following the film up to the fire valve from getting around into the magazine even if the door happens to be open.

4. *Automatic Shutter.*—Must be provided and must be so constructed as to shield the film from the beam of light whenever the film is not running at operating speed. Shutter must be permanently attached to the gate frame.

machines are located so that it will be unnecessary for operator to pass around a burning film or that the likelihood of a burning film being located between himself and the door be reduced to a minimum.

The door to booth should be made to swing outward and be provided with spring hinges so that it will close itself. It

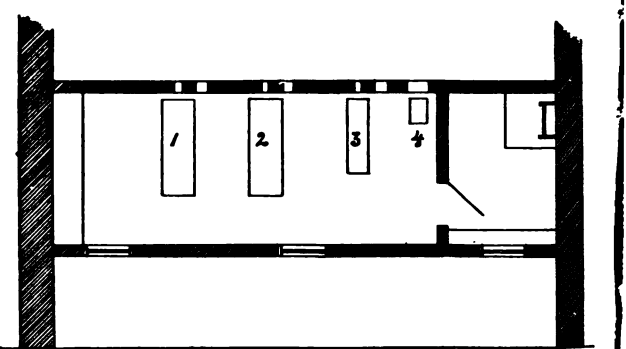


Figure 157.

should open upon a platform level with the floor of booth so as to facilitate the "get away" of the operator as much as possible. It is true that most of the fires that occur in connection with moving pictures machines are due to the carelessness of operators, but much of this carelessness is superinduced by the awkward conditions under which some of them are required to work. Many of them are today working in booths in which it is necessary to crawl on hands and knees to get about. The door should preferably be kept closed but on account of the heated conditions existing in most booths it would be found impossible to enforce such a rule. It will

be well enough if arrangements are such that the door can be readily closed when a fire actually occurs. The door could to advantage be connected with the shutters in such a manner that closing the door would close the shutters. This would cause the shutters to be worked after each show and thus tend to keep them in working order.

The house should have a large vent communicating with the outside air in the ceiling and in order to make proper ventilation possible, there should be openings along bottom of booth. These openings to be covered by fine and strong wire mesh. Nearly all booths are sooner or later provided with fan motors and such a motor might as well be provided and placed so that it will exhaust air through the booth from the auditorium.

The wiring necessary to be introduced into the booth should be run along the ceiling in conduit to point directly above arc lamps so as to reduce amount of loose wire as much as possible. As the ends of wire connecting to arc lamp become very hot and in consequence must be often reconnected it is customary to install them of such a length that there may be considerable slack. This should be neatly coiled up near the ceiling.

The floor of booth should be arranged to be clear of everything. Take up magazines become deranged in one way or another quite frequently and in such a case there is likely to be much film run onto the floor. Many operators are careless enough to finish a show by running onto floor in such cases. When such an accident occurs there is likely to be a bad tangle of film and the less there is in the way on the floor the better it will be for all concerned. Any operator who has once had the experience of trying to straighten out a mess of film and get it back upon the reel while an impatient audience was clapping and calling to him to go on will appreciate this point.

The rheostat if placed within the booth is best suspended a foot or so from the ceiling wherever the height of booth will permit. If placed upon a shelf, rubbish is likely to be stored close to it.

There must be either two or three openings in booth for each moving picture machine. One of these is the "peek hole" through which the operator must view his picture, an-

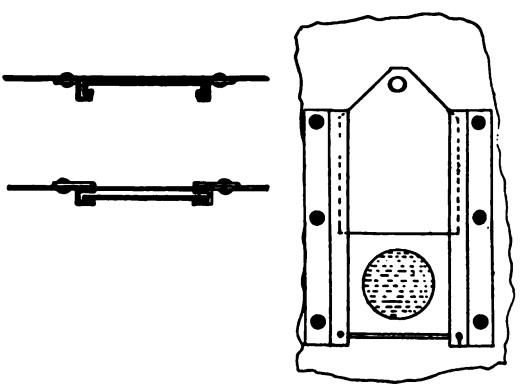


Figure 158.

other for the projection of the picture and generally a third through which the arc lamp may be used in connection with lantern slides. The two last mentioned openings may be very small, in fact, there are a number of booths which have no opening at all a funnel having been built which encloses the beam of light from the projecting lens until it passes out of the house. The "peek hole" may be closed with glass, wire glass being preferred.

The main care should be to keep the audience from

·ing that there is a fire. In a properly arranged and ven-
d booth the film will be burned in a few seconds and
urther harm will be done unless the audience become
tened.

/here openings exist they must be provided with shut-
by which they can be instantly closed in case of fire. The
: majority of such shutters are arranged in guides as
n in Figure 158 and depend upon gravity to close them
ı the supports are released. A sliding shutter is pref-
e because a swinging shutter is more apt to meet with

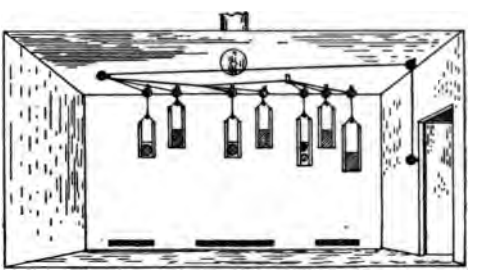


Figure 159.

·uctions in a crowded booth. A sliding shutter may be
)ped with springs to help pull it down if desired. The
es for these shutters should be long enough so that the
er will remain with its full length encased in them
ı open. The shutter should also be of a greater height
width. If it is wider than its height there is great pos-
ty that it may hang a little lower on one side than on the
r and become wedged in sliding down. Many booths are
e up of thin metal. If shutters are placed upon such
; the guides should be strong enough to form substantial
es that will not easily bend and cause the shutter to stick.

Figure 159 shows an inside view of a booth and the arrangement of strings by which they are held open. The main string which supports all of them passes over the top of each machine and traverses the whole length of the booth. No matter in what portion a film may burn it will soon destroy the string and drop all of the shutters. As the string terminates at the door it is convenient for any one to release it when leaving the booth perhaps before the fire has reached the string. Fusible links of the proper kind in series with the string will be an improvement.

8. *Reels Containing Films Under Examination or in Process of Rewinding.*—Must be enclosed in magazines or approved metal boxes similar to those required for films in operation, and not more than two feet of film shall be exposed in booth.

This is one of the most important rules. Operators are very much in the habit of rewinding while operating and this is of course dangerous practice. As with the reels on machine so here it is of great importance to obtain magazines that cannot be operated with doors open. This will at least compel operators to keep films enclosed. Rewinding on open reel while operating machine means that film will be open in booth during the whole run of picture.

Before placing a new outfit in commission a thorough test as to its fireproof qualities should be made. Some old pieces of film should be procured and attempts made to work pieces of burning film through the five valves. No magazine in which this is possible should be used.

Next a piece of film should be threaded into the machine in its proper place and the light, strongly concentrated and with the strongest current ever used (50 to 60 amperes) allowed to strike as much of the light shutter and other parts of frame that may be within the possible range of focused light. The light should be left on each such place for a con-

siderable time so that one feels assured that the film cannot be ignited in this way. If it is possible to ignite film in this manner the machine should be altered to make this impossible.

39. Outline Lighting.

Wiring (Other than Signs on Exterior of Buidings):—

a. Must be connected only to low-potential systems.

b. Open or conduit work may be used, but moulding will not be permitted.

c. For open work, wires must have an approved rubber insulating covering. Must be rigidly supported on non-combustible, non-absorptive insulators, which separate the wires at least one inch from the surface wired over, and must be kept apart at least two and one-half inches for voltages up to 300, and four inches for higher voltages.

Rigid supporting requires, under ordinary conditions where wiring over flat surfaces, supports at least every four and one-half feet. If the wires are liable to be disturbed, the distances between supports should be shortened.

d. Where flexible tubing is required, the ends must be sealed and painted with moisture repellant, and kept at least one-half inch from surface wired over.

e. Wires for use in rigid or flexible steel conduit must comply with requirements for unlined conduit work. Where armored cable is used, the conductors must be protected from moisture by lead sheath between armor and insulation.

f. Must be protected by its own cut-out, and controlled by its own switch. Cut-outs, switches, time switches, flashers and similar appliances, must be of approved design, and must, if located inside the building, be installed as required by the code for such devices. If outside the building they must be inclosed in a steel or cast-iron box.

If a steel box is used, the minimum thickness of the steel must be 0.125 of an inch (No. 11 U. S. gage).

g. Boxes must be so constructed that when switch operates the blade shall clear the door by at least one inch, and they must be moisture proof.

h. Circuits must be so arranged that not more than

1,320 watts will be finally dependent upon a single cut-out; nor shall more than 66 sockets or receptacles be connected to single circuit.

i. Sockets and receptacles must be of the keyless porcelain type, and wires must be soldered to lugs on same.

Wiring for outline lighting is done either in conduit, armored cable or open work. If conduit is used the whole installation should be made watertight. Only such fittings should be used as are provided for threaded joints. The ordinary outlet box with locknut and bushing should never be

Figure 160.

Figure 161.

used for this purpose. If armored cable is used the wires must be covered by a lead sheath and watertight boxes must be used at outlets.

The cheapest construction consists of porcelain receptacles and open wiring. Rubber covered wire and receptacles which give a spacing of one inch from the surface wired over must be used. Receptacles designed for this use are shown in Figures 160 and 161. It will be noted that the wires are raised some distance from the surface on which it is placed to give the required one inch spacing.

All wires must be soldered to the binding posts of re-

ceptacles. This is required as the ordinary handling of the wire when installing is liable to loosen the wire from the binding posts if it is not soldered.

40. Car Wiring and Equipment of Cars.

a. Protection of Car Body, etc.

1. Under side of car bodies to be protected by *approved* fire-resisting, insulating material, not less than one-eighth inch in thickness, or by sheet iron or steel, not less than .04 inch in thickness, as specified in Section *a* 2, 3 and 4. This protection to be provided over all electrical apparatus, such as motors with a capacity of over 75 H. P. each, resistances, contactors, lightning arresters, air-brake motors, etc., and also where wires are run, except that protection may be omitted over wires designed to carry 25 amperes or less if they are encased in metal conduit.

2. At motors of over 75 H. P. each, fire-resisting material or sheet iron or steel to extend not less than 8 inches beyond all edges of openings in motors, and not less than 6 inches beyond motor leads on all sides.

3. Over resistances, contactors and lightning arresters, and other electrical apparatus, excepting when amply protected by their casing, fire-resisting material or sheet iron or steel to extend not less than 8 inches beyond all edges of the devices.

4. Over conductors, not encased in conduit, and conductors in conduit when designed to carry over 25 amperes, unless the conduit is so supported as to give not less than one-half inch clear air space between the conduit and the car, fire-resisting material or sheet iron or steel to extend at least 6 inches beyond conductors on either side.

The fire-resisting, insulating material or sheet iron or steel may be omitted over cables made up of flameproof braided outer covering when surrounded by one-eighth inch flameproof covering, as called for by Section *i*, 4.

5. In all cases fireproof material or sheet iron or steel to have joints well fitted, to be securely fastened to the sills, floor timbers and cross braces, and to have the whole surface treated with a waterproof paint.

6. Cut-out and switch cabinets to be substantially made of hard wood. The entire inside of cabinet to be lined with not less than one-eighth inch fire-resisting, insulating material which shall be securely fastened to the woodwork, and after the fire-resisting material is in place the inside of the cabinet shall be treated with a waterproof paint.

b. **Wires, Cables, etc.**

1. All conductors to be stranded, the allowable carrying capacity being determined by Table "A" of No. 18, except that motor, trolley and resistance leads shall not be less than No. 7 B. & S. gage, heater circuits not less than No. 12 B. & S. gage, and lighting and other auxiliary circuits not less than No. 14 B. & S. gage.

The current used in determining the size of motor, trolley and resistance leads shall be the per cent of the full load current, based on one hour's run of the motor, as given by the following table:—

Size each Motor.	Motor Leads.	Trolley Leads.	Resistance Leads.
75 H. P. or less	50%	40%	15%
Over 75 H. P.	45%	35%	15%

Approved fixture wire will be permitted for wiring *approved* clusters.

2. To have an insulation and braid *approved* for wires carrying currents of the same potential.

3. When run in metal conduit, to be protected by an additional braid.

Where conductors are laid in conduit, not being drawn through, the additional braid will not be required.

4. When not in conduit, in *approved* moulding, or in cables surrounded by one-eighth inch flame-proof covering, must be *approved* rubber covered (except that tape may be substituted for braid) and be protected by an additional flame-proof braid, at least one thirty-second inch in thickness, the outside being saturated with a preservative flame-proof compound, except that when motors are so enclosed that flame cannot extend outside of the casing, the flame-proof covering will not be required on the motor leads.

5. Must be so spliced or joined as to be both mechanically

and electrically secure without solder. The joints must then be soldered and covered with an insulation equal to that on the conductors.

Joints made with *approved* splicing devices and those connecting the leads at motors, plows or third rail shoes need not be soldered.

6. All connections of cables to cut-outs, switches and fittings, except those to controller connection boards, when designed to carry over 25 amperes, must be provided with lugs or terminals soldered to the cable, and securely fastened to the device, by bolts, screws or by clamping; or, the end of the cable, after the insulation is removed, shall be dipped in solder and be fastened into the device by at least two set screws having check nuts.

All connections for conductors to fittings, etc., designed to carry less than 25 amperes, must be provided with up-turned lugs that will grip the conductor between the screw and the lug, the screws being provided with flat washers; or by block terminals having two set screws, and the end of the conductors must be dipped in solder. Soldering, in addition to the connection of the binding screws, is strongly recommended, and will be insisted on when above requirements are not complied with.

This rule only to apply to circuits where the maximum potential is over 25 volts and current exceeds 5 amperes.

c. **Cut-outs, Circuit Breakers and Switches.**

1. All cut-outs and switches having exposed live metal parts to be located in cabinets. Cut-outs and switches, not in iron boxes or in cabinets, shall be mounted on not less than one-fourth inch fire-resisting, insulating material, which shall project at least one-half inch beyond all sides of the cut-out or switch.

2. Cut-outs to be of the *approved* cartridge or *approved* blow-out type.

3. All switches controlling circuits of over 5 ampere capacity shall be of *approved* single pole, quick break or *approved* magnetic blow-out type.

Switches controlling circuits of 5 ampere or less capacity may be of the *approved* single pole, double break, snap type.

5. Where conductors are run in moulding the receptacles or cluster to be mounted on blocks of hard wood or of fireproof insulating material.

g. Heaters and Heating Circuits.

1. Heaters to be of *approved* type.

2. Panel heaters to be so constructed and located that when heaters are in place all current-carrying parts will be at least 4 inches from all woodwork.

Heaters for cross seats to be so located that current-carrying parts will be at least 6 inches below under side of seat, unless under side of seat is protected by not less than one-fourth inch fire-resisting, insulating material, or .04 inch sheet metal with 1 inch air space over same, when the distance may be reduced to 3 inches.

Truss plank heaters to be mounted on not less than one-quarter inch fire-resisting, insulating material, the legs or supports for the heaters providing an air space of not less than one-half inch between the back of the heater and the insulating material.

3. Circuits to be run in *approved* metal conduit, or in *approved* moulding, or if the location of conductors is such as will permit an air space of not less than 2 inches on all sides except from the surface wired over, they may be supported on porcelain knobs or cleats, provided the knobs or cleats are mounted on not less than one-fourth inch fire-resisting, insulating material extending at least 3 inches beyond conductors at either side, the supports raising the conductors not less than one-half inch from the surface wired over, and being not over 12 inches apart.

h. Air Pump Motor and Circuits.

1. Circuits to be run in *approved* metal conduit or in *approved* moulding, except that when run below the floor of the car they may be supported on porcelain knobs or cleats, provided the supports raise the conductors at least one-half inch from the surface wired over and are not over 12 inches apart.

2. Automatic control to be enclosed in *approved* metal box.

3. Air pump and motor, when enclosed, to be in *approved*

metal box or a wooden box lined with metal of not less than one thirty-second inch in thickness.

When conductors are run in metal conduit the boxes surrounding automatic control and air pump and motor may serve as outlet boxes.

i. **Main Motor Circuits and Devices.**

1. Conductors connecting between trolley stand and main cut-out or circuit breakers in hood to be protected where wires enter car to prevent ingress of moisture.

2. Conductors connecting between third rail shoes on same truck, to be supported in an *approved* fire-resisting, insulating moulding, or in *approved* iron conduit supported by soft rubber or other *approved* insulating cleats.

3. Conductors on the underside of the car, except as noted in Section *i*, 4, to be supported in accordance with one of the following methods:—

a. To be run in *approved* metal conduit, junction boxes being provided where branches in conduit are made, and outlet boxes where conductors leave conduit.

b. To be run in *approved* fire-resisting, insulating moulding.

c. To be supported by insulating cleats, the supports being not over 12 inches apart.

4. Conductors with flameproof braided outer coverings, connecting between controllers at either end of car, or controllers and contactors, may be run as a cable, provided the cable where exposed to the weather is encased in a canvas hose or canvas tape, thoroughly taped or sewed at ends and where taps from the cable are made, and the hose or tape enters the controllers.

Conductors with or without flameproof braided outer covering connecting between controllers at either end of the car, or controllers and contactors, may be run as a cable, provided the cable throughout its entire length is surrounded by one-eighth inch flameproof covering, thoroughly taped or sewed at ends, or where taps from cable are made, and the flameproof covering enters the controllers.

Cables where run below floor of car may be

approved insulating straps or cleats. Where run above floor of car, to be in a metal conduit or wooden box painted on the inside with not less than two coats of flameproof paint, and where this box is so placed that it is exposed to water, as by washing of the car floor, attention should be given to making the box reasonably waterproof.

Canvas hose or tape, or flameproof material surrounding cables after conductors are in same, to have not less than two coats of waterproof insulating material.

5. Motors to be so drilled that, on double truck cars, connecting cables can leave motor on side nearest to king bolt.

6. Resistances to be so located that there will be at least 6 inch air space between resistances proper and fire-resisting material of the car. To be mounted on iron supports, being insulated by non-combustible bushings or washers, or the iron supports shall have at least 2 inches of insulating surface between them and metal work of car, or the resistances may be mounted on hard wood bars, supported by iron stirrups, which shall have not less than 2 inches of insulating surface between foot of resistance and metal stirrup, the entire surface of the bar being covered with at least one-eighth inch fire-resisting, insulating material.

The insulation of the conductor, for about 6 inches from terminal of the resistance, should be replaced, if any insulation is necessary, by a porcelain bushing or asbestos sleeve.

7. Controllers to be raised above platform of car by a not less than 1 inch hard wood block, the block being fitted and painted to prevent moisture working in between it and the platform.

j. Lightning Arresters.

1. To be preferably located to protect all auxiliary circuits in addition to main motor circuits.

2. The ground conductor shall be not less than No. 6 B. & S. gage, run with as few kinks and bends as possible, and be securely grounded.

k. General Rules.

1. When passing through floors, conductors or cables must be protected by *approved* insulating bushings, which shall fit the conductor or cable as closely as possible.

2. Moulding should never be concealed except where readily accessible. Conductors should never be tacked into moulding.

3. Short bends in conductors should be avoided where possible.

4. Sharp edges in conduit or in moulding must be smoothed to prevent injury to conductors.

11. Car Houses.

a. The trolley wires must be securely supported on insulating hangers.

b. The trolley hangers must be placed at such a distance apart that, in case of a break in the trolley wire, contact with the floor cannot be made.

c. Must have an emergency cut-out switch located at a proper place outside of the building, so that all the trolley wires in the building may be cut out at one point, and line insulators must be installed, so that when this emergency switch is open, the trolley wire will be dead at all points within 100 feet of the building. The current must be cut out of the building when not needed for use in the building.

This may be done by the emergency switch, or if preferred a second switch may be used that will cut out all current from the building, but which need not cut out the trolley wire outside as would be the case with the emergency switch.

d. All lamps and stationary motors must be installed in such a way that one main switch may control the whole of each installation, lighting and power independently of the main cut-out switch called for in Section *c*.

e. Where current for lighting and stationary motors is from a grounded trolley circuit, the following special rules to apply:—

1. Cut-outs must be placed between the non-grounded side and lights or motors they are to protect. No set or group of incandescent lamps requiring over 2,000 watts must be dependent upon one cut-out.
2. Switches must be placed between non-grounded side and lights and motors they are to protect.
3. Must have all rails bonded at each joint with a conductor having a carrying capacity at least equivalent to No. 0 B. & S. gage annealed copper wire,

Regarding the relative position of switch and fuses it will be noticed that the rule does not forbid the placing of the switch ahead of the fuses. Owing to the high potential generally used with trolley lines, and the fact that the switches and fuses are often handled by men who do not fully realize the life hazard, it is well to install the switch so that the fuse terminals will be dead when the switch is open.

As a curious illustration of what may sometimes occur from imperfect grounding the particulars of a recent electrical fire may be interesting. In a railway station, which was partly of metal and directly connected to a bridge crossing a trolley

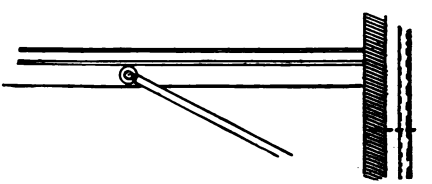


Figure 164.

line, there had been considerable annoyance from so-called "static" discharges for which no cause could be found. One of these discharges resulted in piercing a gas pipe and starting a fire. On investigation the conditions indicated diagrammatically in Figure 164 were found to exist and the cause of the fire determined.

The trolley passed under the metal work of the viaduc and within about one foot of the iron beams of the struc ture. The conditions were such that very frequently th trolley wheel would leave the trolley wire and immediatel make contact with the metal of the structure above. This fac was evidenced by the presence of many burns on the met work.

As a matter of fact the trolley wheel before coming i

The above rule fits the car houses in the smaller cities better than it does those of large cities. In the latter the car house usually consists of a number of bays separated from each other by fire walls and constructed entirely of fireproof material. There is never anything in these bays that could burn with the exception of the cars themselves. It is advisable to arrange each bay with a service switch in addition to those called for by the rule. It will then be generally found that the main switch need not be used.

The rule allows the use of single pole switches on lighting from grounded trolley circuits. So long as the ground con-

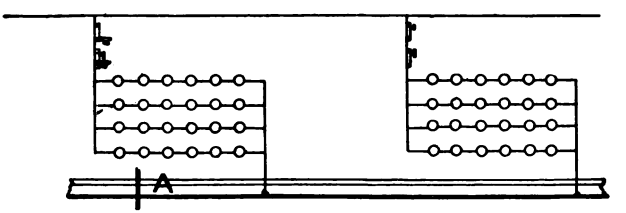


Figure 163.

nections are in good condition this is all that is necessary. In car houses, etc., where it is most likely that such method of lighting will be used the rails are generally relied upon to furnish at least part of the ground connection. These rails are often taken up or disconnected so that the breaking of the ground connection is always a possibility.

Referring to Figure 163, should such a break or bad condition exist at A and the group of lights at the right be turned on, a man working on the group of lights at the left might be severely injured even though the switch was disconnected.

to severe external heat, must be approved, rubber-covered and not smaller in size than No. 12 B. & S. Insulation on wires between resistances and contact plates of rheostats must conform to Section *d*, while wires subjected to severe external heat must have approved slow-burning insulation.

2. All wires excepting collector wires and those run in metal conduit or approved flexible cable must be supported by knobs or cleats which separate them at least one inch from the surface wired over, but in dry places where space is limited and the distance between wires as required by Rule 26*h* cannot be obtained, each wire must be separately encased in approved flexible tubing securely fastened in place.

Collector wires must be supported by approved insulators so mounted that even with the extreme movement permitted the wires will be separated at all times at least 1½ inches from the surface wired over. Collector wires must be held at the ends by aproved strain insulators.

3. Main collector wires carried along the runways must be rigidly and securely attached to their insulating supports at least every 20 feet, and separated at least 6 inches when run in a horizontal plane; if not run in a horizontal plane, they must be separated at least 8 inches. If spans longer than 20 feet are necessary the distance between wires must be increased proportionately but in no case shall the span exceed 40 feet.

4. Where bridge collector wires are over 80 feet long, insulating supports on which the wires may loosely lie must be provided at least every 50 feet.

Bridge collector wires must be kept at least 2½ inches apart, but a greater spacing should be used whenever it may be obtained.

5. Collector wires must not be smaller in size than specified in the following table for the various spans.

Distance between rigid supports.	Size wire required.
Feet.	B. & S.
0 to 30	6
31 to 60	4
Over 60	2

b. **Collectors.**

Must be so designed that sparking between them and collector wires will be reduced to a minimum.

c. **Switches and Cut-outs.**

1. The main collector wires must be protected by a cut-out and the circuit controlled by a switch. Cut-out and switch to be so located as to be easy of access from the floor.

2. Cranes operated from cabs must have a cut-out and switch connected into the leads from the main collector wires and so located in the cab as to be readily accessible to the operator.

3. Where there is more than one motor on a single crane, each motor lead must be protected by a cut-out located in the cab if there is one.

d. **Controllers.**

Must be installed according to No. 4, except that if the crane is located out doors the insulation on wires between resistances and contact plates of rheostats must be rubber where the wires are exposed to moisture and insulation is necessary and also where they are grouped. If the crane operates over readily combustible material, the resistance must be placed in an enclosure made of non-combustible material, thoroughly ventilated and so constructed that it will not permit any flame or molten metal to escape in the event of burning out the resistances. If the resistances are located in the cab, this result may be obtained by constructing the cab of non-combustible material and providing sides which enclose the cab from its floor to a height at least 6 inches above the top of the resistances.

e. **Grounding of Iron Work.**

The motor frames, the entire frame of the crane and the tracks must be permanently and effectually grounded.

Electric cranes are made in a variety of design and sizes, varying from the small crane operated from the ground and provided with a single motor, to the larger cranes with four or five motors.

The more common form of crane such as is used in large shops and other locations where it is necessary to move heavy loads consists of an iron bridge elevated some distance and carried on wheels which rest on tracks which are supported by the building walls or by special steel structures.

These cranes consist of three principal parts; the bridge, the trolley and the hoist.

The hoist is operated by a motor geared to a drum and is generally the heaviest motor on the crane.

The bridge motor moves the load in a transverse direction, or across the bridge.

The trolley motor moves the bridge along the runway.

These motors are controlled from a cab attached to the bridge the current being carried to the movable bridge, and from the bridge to the hoist motor, by trolley wires fastened along the steel work on which rest trolley wheels or shoes.

The usual processes in the operation of a crane are: the hoisting of the load, the movement of the load across the bridge and the movement of the bridge and load along the runway. The order of these operations may be reversed or they may occur together and it is possible to have all motors on a crane operating at one time. For this reason, and for the further reason that cranes are often overloaded, the wires should be of ample size to carry all motors running at one time.

It will be noted that the rule does not require a separate switch for each motor. There must be a main switch located in the cab (if there is one) which will cut off all motors and the starting devices. This switch must be double pole for direct current systems and three-pole for three-phase systems. There must also be a cut-out for each motor circuit; if the crane contains three motors there must be three cut-

outs. For direct currents these cut-outs must be double-pole and for three-phase systems three-pole.

There must also be a cut-out and switch located within reach from the ground and so arranged that the entire crane including trolleys, cab, motor, etc., can be cut dead.

The rule describes the method of wiring allowed and these rules should be closely followed. Open wiring is very liable to mechanical injury. Conduit work will often save costly interruption of service and is to be recommended. The practice of wiring cranes with flexible tubing is not advisable for the same reason and for the further reason that it is almost as expensive as conduit work while its life is much shorter.

All collector wires must be supported at the ends by *approved* strain insulators. Insulators such as are shown at 2 Figure 53 should be used. Porcelain or glass circuit breakers such as shown in Figure 63 should not be used.

The collector wires are sometimes arranged to be fastened at each end by strain insulators and at intermediate points rest loosely on insulating supports. This is done to allow the use of contact shoes which make contact on the under side of trolley wires. Such shoes need not be adjustable as the free movement of the trolley wire allows for slight variations in the travel of the shoe. This construction is not in strict accordance with the rule which requires the trolley wire to be "rigidly" attached to the insulating supports. It is, however, extensively used. Supports as just described greatly lessen the tension on the wire, in fact relieve the tension just as much as though rigidly supported. The objection to this construction lies in the fact that if the trolley wire should break it would probably fall to the ground.

While the steel structure cannot be used as a return for the current it is liable at any time to become alive due to

ground on the wiring system and as the structure is li
be insulated from the earth on masonry columns it i
essential that it be effectively grounded.

HIGH-POTENTIAL SYSTEMS.

550 TO 3,500 VOLTS.

Any circuit attached to any machine or combination chines which develops a difference of potential betwe two wires of over 550 volts and less than 3,500 volt be considered at a high-potential circuit, and as com der that class, unless an approved transforming de used, which cuts the difference of potential down volts or less. For 550 volt motor equipments a ma ten per cent above the 550 volt limit will be allowed generator or transformer without coming under h tential systems.

44. Wires.

(See also Nos. 16, 17 and 18. For construction rules se 49 and 50.)

a. Must have an *approved* rubber-insulating coveri

b. Must be always in plain sight and never encas cept as provided for in No. 8 *b*, or where required by spection Department having jurisdiction.

c. Must (except as provided for in No. 8 *b*), be supported on glass or porcelain insulators, which raise tl at least one inch from the surface wired over, and n kept about eight inches apart.

Rigid supporting requires under ordinary conditions, wiring along flat surfaces, supports at least about eve and one half feet. If the wires are unusually liable to turbed, the distance between supports must be shorte

In buildings of mill construction, mains of not les No. 8 B. & S. gage, where not liable to be disturbed, r separated about ten inches and run from timber to timb breaking around, and may be supported at each timbe

d. Must be protected on side walls from mechanical injury by a substantial boxing, retaining an air space of one inch around the conductors, closed at the top (the wires passing through bushed holes) and extending not less than seven feet from the floor. When crossing floor timbers, in cellars, or in rooms where they might be exposed to injury, wires must be attached by their insulating supports to the under side of a wooden strip not less than one-half an inch in thickness.

With the exception of series arc systems, which are fast going out of use, high potential wires are seldom brought into buildings. About the only cases where it is necessary to bring high tension wires into a building are for motor installations, which are provided for in No. 8 b, and installations where the transformers are placed inside of the building as provided in No. 45. In both of these cases special precautions are necessary.

45. Transformers. (When permitted inside buildings under No. 14.)

(See also Nos. 11, 14, 15 and 36. For construction of Transformers see No. 81.)

Transformers must not be placed inside of buildings without special permission from the Inspection Department having jurisdiction.

a. Must be located as near as possible to the point at which the primary wires enter the building.

b. Must be placed in an enclosure constructed of fire-resisting material; the enclosure to be used only for this purpose, and to be kept securely locked, and access to the same allowed only to responsible parties.

c. Must be thoroughly insulated from the ground, or permanently and effectually grounded, and the enclosure in which they are placed must be practically air-tight, except that it must be thoroughly ventilated to the outdoor air, if possible through a chimney or flue. There should be at least six inches air space on all sides of the transformer.

The practice of placing transformers inside of buildings should be discouraged. It is much better to place them on poles or in manholes or specially constructed buildings for in these locations they are less liable to be the cause of fatal accidents. When placed inside of a building the low potential mains should be fused outside of the transformer room and the installation should be otherwise arranged to make it unnecessary for any one other than an employe of the lighting company to ever enter the room and all keys to these rooms should be held by the companies employes only.

In the construction of transformer rooms inside of buildings it is well to provide for proper drainage. A ledge should be placed at all door openings of sufficient height to keep any oil which might leak out of the transformer from flowing into the building.

The rule allows either grounding or insulating of transformer case. It is generally considered, however, that the grounding is preferable as a safeguard to life. With a grounded case it is also impossible for a contact to be made between the high potential wires and the low potential wires through the case.

46. Series Lamps.

a. No multiple series or series multiple system of lighting will be approved.

b. Must not, under any circumtsances, be attached to gas fixtures.

EXTRA-HIGH-POTENTIAL SYSTEMS.

OVER 3,500 VOLTS.

Any circuit attached to any machine or combination of machines which develops a difference of potential, between any two wires, of over 3,500 volts, shall be considered as an extra-high-potential circuit, and as coming under that class, unless an approved transforming device is used, which cuts the difference of potential down to 3,500 volts or less.

47. Primary Wires.

a. Must not be brought into or over buildings, except power stations and sub-stations.

48. Secondary Wires.

a. Must be installed under rules for high-potential systems when their immediate primary wires carry a current at a potential of over 3,500 volts, unless the primary wires are installed in accordance with the requirements as given in No. 13 or are entirely underground, within city, town and village limits.

Every completed single conductor shall be tested by passing it through a spring metal spiral not less than 6 inches long, so formed as to come in contact with all points on the circumference of the wire, while a voltage of not less than 500 volts for one sixty-fourth inch insulation, not less than 1,000 volts for one thirty-second inch insulation or not less than 1,500 volts for three sixty-fourths inch insulation is applied to the conductor and to the spiral.

The completed cord shall be subjected to a 1 minute test between conductors of 1,000 volts for one sixty-fourth inch insulation, 2,000 volts for one thirty-second inch insulation and 2,500 volts for three sixty-fourths inch insulation.

The insulating coverings in the above tests shall be sufficient to resist puncture or breakdown. The source of electromotive force shall be the same as that specified in No. 50 *c*.

c. Must have on outer protecting covering as follows:—

1. *For Pendant Lamps.*—(Type Letter C.) (See Figure 167.) In this class is to be included all flexible cord, which, under usual conditions, hangs freely in air, and which is not likely to be moved sufficiently to come in contact with surrounding objects.

It should be noted that pendant lamps provided with long cords, so that they can be carried about or hung over nails, or on machinery, etc., are not included in this class, even though they are usually allowed to hang freely in air.

Each conductor must have an approved braided covering so put on and sealed in place that when cut it will not fray out.

For use in damp places (Type Letters C. Wp.) the insulation must be at least three sixty-fourths of an inch thick

Figure 167.

and the braided coverings must either be thoroughly saturated with a moisture proof preservative compound or be enclosed in an outer braided moisture-proof preservative covering over the whole.

It will be specially noted that the thickness of rubber on cords for use in damp places must be not less than 3/64th of an inch. The object is to obtain a substantial thickness of rubber between wires of opposite polarity. "Portable" cord, "packing houses" cord, "brewery" cords and other cords of similar construction having only a 1/32d inch rubber insulation must not be used in damp places.

2. *For Portables.*—(Type Letter P.) (See Figure 168.) Flexible cord for portable use except in offices, dwellings or

Figure 168.

similar places, where cord is not liable to rough usage and where appearance is an essential feature, must meet all the requirements for flexible cord for pendants and in addition must have a tough, braided cover over the whole. There must also be an extra layer of rubber between the outer cover and the flexible cord.

For use in damp places (Type Letters P. Wp.) the insulation must be at least three sixty-fourths of an inch thick and

Figure 169.

the cord must have its outer covering saturated with a moisture-proof preservative compound thoroughly slicked down or must have a filler of approved material instead of the extra layer of rubber and have two outer braids saturated with a moisture-proof compound with the exterior surface thoroughly slicked down.

In offices, dwellings, or in similar places (Type Letters P. O.) (see Figure 169), where cord is not liable to rough usage and where appearance is an essential feature, flexible

separator, if one is used, and of a thickness not less than that given in the following tables, Sections *e* and *f*.

Measurements of insulating wall are to be made at the thinnest portion of the dielectric.

c. Any one foot sample of completed covering must show a dielectric strength sufficient to resist throughout five minutes the application of an electro-motive force proportionate to the thickness of insulation in accordance with the following table:—

Thickness in 64ths inches.	Breakdown test on 1 foot.
1	3,000 volts A. C.
2	6,000 " "
3	9,000 " "
4	11,000 " "
5	13,000 " "
6	15,000 " "
7	16,500 " "
8	18,000 " "
10	21,000 " "
12	23,500 " "
14	26,000 " "
16	28,000 " "

The source of alternating electro-motive force shall be a transformer of at least one kilowatt capacity. The application of the electro-motive force shall first be made at 3,000 volts for five minutes, then the voltage increased by steps of not over 3,000 volts, each held for five minutes, until the rupture of the insulation occurs. The tests for dielectric strength shall be made on a sample wire which has been immersed in water for seventy-two hours. One foot of the wire under test is to be submerged in a conducting liquid held in a metal trough, one of the transformer terminals being connected to the copper of the wire and the other to the metal of the trough.

d. Every length of completed wire or cable must be tested after not less than 12 hours immersion in water, and while still immersed by the application for one minute of an alternating current voltage derived from apparatus of ample capacity, the test voltages to be those given in the tables of Sections *e* and *f*.

ductors, each of a capacity not exceeding No. 4 B. & S. gage, each of which shall be built up of wires not larger than No. 26 B. & S. gage. Each conductor to have a tight close wind of cotton, or some other approved method must be employed to prevent a broken strand puncturing the insulation and to keep the rubber compound from corroding the copper. The insulation proper to be of rubber complying with No. 50 *b* and *d* and with requirements of No. 50 *c*, except that insulations less than three sixty-fourths of an inch in thickness (conductors having a capacity less than No. 14 B. & S. gage wire) must show an insulation resistance of not less than 50 megohms per mile during two weeks' immersion in water at 70 degrees Fahrenheit (21 degrees Centigrade), must have on each conductor an outer protective braided covering properly saturated with a preservative compound. The conductors to be twisted together, a filler of *approved* material being used

Figure 171.

to make cable round and to act as a cushion, and finished with two weatherproof braids over the whole.

The completed cable must be of such a flexible nature as to be readily handled, and when laid on the floor must align itself to the floor level.

f. Border Cables.—(Type Letter B.) (See Figure 172.) Shall consist of flexible copper conductors, each of which shall be built up of wires not larger than No. 26 B. & S. gage. Each conductor to have a tight close wind of cotton, or some other approved method must be employed to prevent a broken strand puncturing the insulation, and to keep the rubber compound from corroding the copper. The insulation proper to be of rubber complying with requirements of No. 50 *b, c* and *d,* must have on each conductor an outer protective braided covering properly saturated with a preservative compound. The conductors to be cabled together and finished with two weatherproof braids over the whole.

g. Elevator Lighting and Control Cables.—(Type Letter E.) Must comply with the requirements for threatre cable as

Size	Thickness in 64ths inchs.	Megohms per mile after 12 hrs. immersion.	Voltage Test one minute.
6	1-16	200	2,000
4	1-16	150	2,000
2	1-16	125	2,000
1	5-64	150	2,500
0	5-64	125	2,500
00	5-64	125	2,500
000	5-64	100	2,500
0000	5-64	100	2,500
225,000 C. M.	3-32	100	3,000
300,000 C. M.	3-32	100	3,000
400,000 C. M.	3-32	100	3,000
500,000 C. M.	3-32	100	3,000
600,000 C. M.	7-64	100	3,500
700,000 C. M.	7-64	100	3,500
800,000 C. M.	7-64	100	3,500
900,000 C. M.	7-64	100	3,500
1,000,000 C. M.	7-64	100	3,500
1,250,000 C. M.	1-8	100	3,500
1,500,000 C. M.	1-8	75	3,500
1,750,000 C. M.	1-8	60	3,500
2,000,000 C. M.	1-8	50	3,500

f. **Tests on completed lengths 601 to 7,000 Volt.**

Max. Operating Voltage.
1,500 V. Type Letters R. S.—15.

Size.	Thick Ins.	Ins. Res. Meg.	Volts Test.
B. & S. Gage			
14-8	1-16	600	4,000
7-2	5-64	300	4,000
1-0000	3-32	200	4,000
C. M.			
225,000-500,000	7-64	175	4,000
525,000-1,000,000	1-8	150	4,000
Over 1,000,000	9-64	100	4,000

Max. Operating Voltage.

2,500 V. Type Letters R. S.—25.

Size.	Thick Ins.	Ins. Res. Meg.	Volts Test.
B. & S. Gage			
14-8	3-32	700	6,250
7-2	3-32	350	6,250
1-0000	7-64	250	6,250
C. M.			
225,000-500,000	1-8	200	6,250
525,000-1,000,000	9-64	175	6,250
Over 1,000,000	10-64	125	6,250

Max. Operating Voltage.

3,500 V. Type Letters R. S.—35.

Size.	Thick Ins.	Ins. Res. Meg.	Volts Test.
B. & S. Gage			
14-8	4-32	850	8,750
7-2	4-32	450	8,750
1-0000	4-32	300	8,750
C. M.			
225,000-500,000	9-64	225	8,750
525,000-1,000,000	10-64	200	8,750
Over 1,000,000;	11-64	150	8,750

Max. Operating Voltage.

5,000 V. Type Letters R. S.—50.

Size.	Thick Ins.	Ins. Res. Meg.	Volts Test.
B. & S. Gage			
14-8	6-32	1,000	12,500
7-2	6-32	650	12,500
1-0000	6-32	450	12,500
C. M.			
225,000-500,000	6-32	300	12,500
525,000-1,000,000	6-32	225	12,500
Over 1,000,000	7-32	175	12,500

of an inch in thickness for wires larger than No. 10 B. & S. gage, and at least one sixty-fourth of an inch in thickness for wires No. 10 B. & S. gage or less in size; this fibrous covering to be sufficiently tenacious to withstand abrasion of being hauled through the metal conduit. (Figures 175 and 176.)

b. For twin or duplex wires in lined conduit, each conductor must comply with the requirements of No. 50 (except that tape may be substituted for braid on the separate conductors), and must have a substantial braid covering the

Figure 174.

Figure 175.

Figure 176.

whole. For unlined conduit each conductor must comply with requirements of No. 50 (except that tape may be substituted for braid), and in addition must have a braid covering the whole, at least one thirty-second of an inch in thickness and sufficiently tenacious to withstand the abrasion of being hauled through the metal conduit. (Figure 177.)

c. For concentric wire, the inner conductor must comply with the requirements of No. 50 (except that tape may be substituted for braid), and there must be outside of the outer conductor the same insulation as on the inner, the whole to be covered with a substantial braid, which for unlined conduits must be at least one thirty-second of an inch in thick-

Figure 177.

Figure 178.

ness, and sufficiently tenacious to withstand the abrasion of being hauled through the metal conduit. (Figure 178.)

d. The braids or tapes called for in sections *a*, *b* and *c*, must be properly saturated with a preservative compound.

The braid or tape required around each conductor in duplex, twin and concentric cables is to hold the rubber insulation in place and prevent jamming and flattening.

New wire.—A test piece taken from the wire, having insulation less than five sixty-fourths inch thick, shall have marks placed 2 inches apart, and shall be stretched longitudinally at the rate of 12 inches per minute till the marks are 5 inches apart, and then be immediately released and a measurement taken 30 seconds thereafter, when the distance between the marks must not exceed 2.5 inches. The test piece shall then be stretched until the marks are 6 inches apart before rupture. The tensile strength shall not be less than 400 lbs. per square inch, calculated upon the original cross section of the test piece before stretching.

Test pieces from wire having insulation five sixty-fourths inch thick or over shall be tested in a similar manner, but shall be stretched to 4 inches instead of 5 inches, and must not break until stretched 5 inches, and shall have a tensile strength of 400 lbs. per square inch.

Wire tested at any time up to one year from date of manufacture.—A test piece taken from wire having insulation less than five sixty-fourths inch thick shall have marks placed 2 inches apart, and shall be stretched longitudinally at the rate of 12 inches per minute till the marks are 4 inches apart, and then be immediately released and a measurement taken 30 seconds thereafter, when the distance between the marks must not exceed 2.5 inches.

Test pieces from wire having insulation five sixty-fourths inch or over shall be stretched to 3½ inches instead of 4 inches.

h. All of the above insulations must be protected by a substantial braided covering, properly saturated with a preservative compound. This covering must be sufficiently strong to withstand all the abrasions likely to be met with in practice, and must substantially conform to approved samples submitted by the manufacturer.

i. Five chemical tests shall be made of the rubber compound as follows: Acetone extract, alcoholic potash extract, chloroform extract, ash and total sulphur.

The sum total of the results of these five tests shall not exceed 80 per cent by weight of the total compound.

The ash test shall be supplemented by tests to determine the quantity of substances other than vulcanized rubber, which are combustible, but not soluble in acetone, alcoholic potash,

or chloroform, and any such substance shall be counted as ash.

Tests to be made according to Underwriters' Laboratories specifications.

Lead Covered Wires and Cables for Interior Work Only.

(Type letters R. S. L.)

j. The thickness of insulating wall of lead sheath rubber insulated conductors 0-600 volts to be the same as for braided cables, all cables to be covered with a compound filled tape or braid over the insulating wall. If braid is used, it shall be of such a thickness as to increase the required diameter over the insulating wall by at least one thirty-second of an inch, and must comply with the requirements for braid on braided conductors.

If tape is used it must not be less than one sixty-fourth of an inch thick and must lap at least one-fourth of its width. The width of the tape used should not exceed twice the square root of the diameter of the conductor over the insulating wall; *i. e.*, 500,000 C. M. three thirty-seconds rubber, tape not to exceed 2 inches in width; No. 14, three sixty-fourths rubber, tape should not exceed .8 inches in width.

The lead on single conductor cables, 0-600 volt class, sizes 2 B. & S. and smaller, both solid and stranded, to be not less than the thickness of rubber called for by Section *e*. On larger sizes the thickness of lead to be not less than the thickness of insulating wall called for, less one sixty-fourth of an inch; *i. e.*, thickness of lead on No. 2, one-sixteenth inch; on 1,000,000 C. M., three thirty-seconds inch. On multiple conductor cables, thickness of lead to be that called for by single conductor, having same diameter over the insulation as the multiple conductor cable has over the bunched insulated conductors.

Rubber insulated and lead sheathed cables, 601 to 7,000 volt classes inclusive (Type letters R. S. L—15, R. S. L—25, etc.) shall comply with Section *f*, and the lead sheath shall be the same as called for in 0-600 volt class, having same diameter under the lead as 601-7,000 volt conductor.

(Electrical test on finished leaded cables the same as on braided.)

It will be noted that the specifications governing the construction and testing of rubber covered wire have been

greatly amplified and made much more rigid. The previous specifications allowed a wire of rather poor insulating quality and the statement has been made that "rubber covered wire," the insulating covering of which was entirely devoid of rubber, has been made to stand the tests.

The present specifications have been drawn up in such a manner as to demand a very good insulating covering for the wire, requiring a rubber compound with about 20% of rubber.

In the stretch test a ready method of roughly testing the wire in the field has been provided. To make this test remove the braid carefully and strip the entire rubber insulating covering from the wire. Place two marks two inches apart and test the wire by stretching it as directed. "New" wire is wire not over thirty days old and should stretch to five inches and back to two and one-half inches. Wire over thirty days old shall be stretched to 4 inches and should then return to two and one-half inches.

51. Slow-burning Weatherproof Wire. (Type Letters S. B. W.)

(See Figure 165.)

(For installation rules see No. 26 h.)

This wire is not as burnable as "weatherproof" nor as subject to softening under heat. It is not suitable for outside work.

a. The insulation must consist of two coatings, one to be fireproof in character and the other to be weatherproof. The

Figure 165.

fireproof coating must be on the outside and must comprise about six-tenths of the total thickness of the wall. The completed covering must be of a thickness not less than that given in the following table:—

duits must be such as to afford under conditions likely to be met in practice, protection substantially equivalent in all respects to that afforded by rigid unlined metal conduits.

59. Outlet, Junction and Flush Switch Boxes.

(See Figure 182.)

(For installation rules see Nos. 27 and 28. For boxes for panel-boards, cut-outs and switches other than flush switches see No. 70.)

a. Must be of pressed steel having wall thickness not less than .078 inch (No. 14 U. S. metal gage), or of cast metal having wall thickness not less than one-eighth inch. Junction boxes of larger sizes must comply with requirements of No. 70, but must in all cases be of metal.

b. Must be well galvanized, enameled or otherwise properly coated, inside and out, to prevent oxidation.

It is recommended that the protective coating be of conductive material such as tin or zinc.

c. Must be so made that all openings not in use will be effectively closed by metal which will afford protection substantially equivalent to the walls of the box.

Fittings which are designed for bringing conductors from metal conduits to exposed wiring must be provided with non-absorptive, non-combustible, insulating bushings, which, except with flexible cord, must separately insulate each conductor.

d. Must be plainly marked, where it may readily be seen when installed, with the name or trademark of the manufacturer.

e. Must, in case of combination gas and electric outlets, be so arranged that connection with gas pipe at outlet may be made by means of an approved device.

Must be arranged to secure in position the conduit or flexible tubing protecting the wire.

This rule will be complied with if the conduit or tubing is firmly secured in position by means of some *approved* device which may or may not be a part of the box.

f. Boxes used with lined conduit must comply with the foregoing requirements, and in addition must have a tough

and tenacious insulating lining at least one thirty-second inch thick, firmly secured in position.

g. Switch and outlet boxes must be so arranged that they can be securely fastened in place independently of the support afforded by the conduit piping, except that when entirely exposed, *approved* boxes, which are threaded so as to be firmly supported by screwing on to the conduit pipe, may be used.

Figure 182.

h. Switch boxes must completely enclose the switch on sides and back, and must provide a thoroughly substantial support for it. The retaining screws for the box must not be used to secure the switch in position.

i. Covers for outlet boxes if made of metal must be equal in thickness to that specified for the walls of the box, or must be of metal lined with an insulating material not less than one thirty-second inch in thickness, firmly and permanently secured to the metal. Covers may also be made of porcelain or other approved material, provided they are of such form and thickness as to afford suitable protection and strength.

60. Mouldings.

(For installation rules see Nos. 26 k to m.)

Wooden Mouldings.

a. Must have, both outside and inside, at least two coats of waterproof material, or be impregnated with a moisture repellent.

d. Sizes.

Dimensions of wall and heads must be at least as great as those given in the following table:—

Diameter of Hole.	External Diameter.	Thickness of Wall.	External Diameter of Head.	Length of Head.
5/16 in.	9/16 in.	1/8 in.	13/16 in.	1/2 in.
3/8	11/16	5/32	1 1/16	1/2
1/2	13/16	5/32	1 3/16	1/2
5/8	1 1/16	5/32	1 5/16	1/2
3/4	1 3/16	7/32	1 11/16	5/8
1	1 7/16	7/32	1 15/16	5/8
1 1/4	1 13/16	9/32	2 5/16	5/8
1 1/2	2 3/16	11/32	2 11/16	3/4
1 3/4	2 9/16	13/32	3 1/16	3/4
2	2 15/16	15/32	3 7/16	3/4
2 1/4	3 5/16	17/32	3 13/16	1
2 1/2	3 11/16	19/32	4 3/16	1

An allowance of one sixty-fourth of an inch for variation in manufacturing will be permitted, except in the thickness of the wall.

62. Cleats.

a. Construction.

(See Figure 185.)

Must hold the wire firmly in place without injury to its covering.

Sharp edges which may cut the wire should be avoided.

b. Supports.

Bearing points on the surface must be made by ridges or rings about the holes for supporting screws, in order to avoid cracking and breaking when screwed tight.

c. Material and Test.

Must be made of non-combustible, insulating material, which, when broken and submerged for 100 hours in pure water at 70 degrees Fahrenheit (21 degrees Centigrade), will not absorb over one-half of one per cent of its weight.

d. **Marking.**

Must have the name, initials or trade-mark of the manufacturer stamped in the ware.

e. **Sizes.**

Must conform to the spacings given in the following table:—

Voltage.	Distance from Wire to Surface.	Distance between Wires.
0-300	½ inch	2½ inches

This rule will not be interpreted to forbid the placing of the neutral of a three-wire system in the center of a three-wire cleat where the difference of potential between the outside wires is not over 300 volts, provided the outside wires are separated two and one-half inches.

63. Flexible Tubing.

(See Figure 186.)

(For installation rules see No. 26 e. s and u.)

a. Must have a sufficiently smooth interior surface to allow the ready introduction of the wire.

Figure 185.

b. Must be constructed of or treated with materials which will serve as moisture repellents.

c. The tube must be so designed that it will withstand all the abrasion likely to be met with in practice.

d. The linings, if any, must not be removable in lengths of over three feet.

e. The one-fourth inch tube must be so flexible that it will not crack or break when bent in a circle with six-inch radius at 50 degrees Fahrenheit (10 degrees Centigrade, and

the covering must be thoroughly saturated with a dense moistureproof compound which will not slide at 150 degrees Fahrenheit (65 degrees Centigrade). Other sizes must be as well made.

f. Must not convey fire on the application of a flame from Bunsen burner to the exterior of the tube when held in a vertical position.

g. Must be sufficiently tough and tenacious to withstand severe tension without injury; the interior diameter must not

Figure 186.

be diminished or the tube opened up at any point by the application of a reasonable stretching force.

h. Must not close to prevent the insertion of the wire after the tube has been kinked or flattened and straightened out.

i. Must have a distinctive marking the entire length of the tube, so that tubing may be readily identified in the field.

64. Knobs.

a. Construction.

Split knobs must be constructed in two parts, a base and a cap, arranged to hold the wire firmly in place without injury to its covering. Sharp edges must be avoided. Solid knobs must be constructed with smooth groove, to contain wire.

b. Supports.

Bearing points on the surface wired over must be made by a ring or by ridges on the outside edge of the base, to provide for stability. At least one-fourth inch surface separation must be maintained between the supporting screw or nail and the conductor, and the knob must be so constructed that the supporting screw or nail cannot come in contact with the conductor. For wires larger than No. 4 B. & S. gage, split knobs (or single wire cleats) must be so constructed as to require the use of two supporting screws.

Material and Test.

Must be made of non-combustible, insulating material, which, when broken, and submerged for one hundred hours in pure water at 70 degrees Fahrenheit (21 degrees Centigrade) will not absorb one-half of one per cent of its weight.

Marking.

Must have the name, initials or trade-mark of the manufacturer stamped in the ware.

Sizes.

Must be so constructed as to separate the wire at least one inch from the surface wired over, and also conform to the following minimum dimensions:—

Size of Wire Inclusive.	Size of Base, Inches.			Solid Knobs, Groove, Inches.		Split Knobs, Thickness of Cap, Inches from Top of Wire Groove.
	Circular Knobs, Diameter.	Square Knobs or Single Wire Cleats.				
		Width.	Length.	Depth.	Diameter.	
14-1	1⅛	¾	1¾	3/16	¼	5/8
8-4	1½	⅞	2	5/16	5/16	5/8
2-00	2	1	2¼	7/16	⅝	⅝
00-300,000 C. M.	2½	1⅛	2¾	7/16	11/16	⅞
400,000-1,000,000 C. M.	3	1⅜	3¾	⅝	1¼	1

(For installation rules see Nos. 8 c, 19 20 b and 24.)

General Rules.

a. Must, when used for service switches, indicate, on inspection, whether the current be "on" or "off."

b. Must, for constant-current systems, close the main circuit and disconnect the branch wires when turned "off;" must be so construced that they shall be automatic in action, not stopping between points when started, and must prevent an arc between the points under all circumstances. They must indicate whether the current be "on" or "off."

Knife Switches.

(See Figure 187.)

Knife switches must be made to comply with the following Specifications, except in those few cases where peculiar design allows the switch to fulfill the general requirements in some other way, and where it can successfully withstand the test of Section i. In such cases the switch should be submitted for special examination before being used.

c. Base.

Must be mounted on non-combustible, non-absorptive, insulating bases. Other materials than slate, marble or porcelain must be submitted for special examination before being used. Bases with an area of over twenty-five square inches must have at least four supporting screws. Holes for the supporting screws must be so located or countersunk that there will be at least one-half of an inch space, measured over the surface, between the head of the screw or washer and the nearest live metal part, and in all cases when between parts of opposite polarity must be countersunk.

d. Mounting.

Pieces carrying the contact jaws and hinge clips must be secured to the base by at least two screws, or else made with a square shoulder, or provided with dowel-pins, to prevent possible turnings, and the nuts or screw-heads on the under side of the base must be countersunk not less than one-eighth inch and covered with a waterproof compound which will not melt below 150 degrees Fahrenheit (65 degrees Centigrade).

Hinges.

Hinges of knife switches must not be used to carry current unless they are equipped with spring washers, held by lock-nuts or pins, or their equivalent, so arranged that a firm and secure connection will be maintained at all positions of the switch blades.

Spring washers must be of sufficient strength to take up any wear in the hinge and maintain a good contact at all times.

Metal.

All switches must have ample metal for stiffness and to prevent rise in temperature of any part of over 50 degrees Fahrenheit (28 degrees Centigrade), at full load, the contacts being arranged so that a thoroughly good bearing at

Figure 187.

every point is obtained with contact surfaces advised for pure copper blades of about one square inch for each seventy-five amperes; the whole device must be mechanically well made throughout.

Cross-Bars.

All cross-bars less than three inches in length must be made of insulating material. Bars of three inches and over, which are made of metal to insure greater mechanical strength, must be sufficiently separated from the jaws of the switch to prevent arcs following from the contacts to the bar on the opening of the switch under any circumstances. Metal bars should preferably be covered with insulating material.

To prevent possible turning or twisting the cross-bar must

be secured to each blade by two screws, or the joints made with square shoulders or provided with dowel-pins.

h. Connections.

Switches for currents of over thirty amperes must be equipped with lugs, firmly screwed or bolted to the switch, and into which the conducting wires shall be soldered. For the smaller sized switches simple clamps can be employed, provided they are heavy enough to stand considerable hard usage.

Where lugs are not provided, a rugged double-V groove clamp is advised. A set screw gives a contact at only one point, is more likely to become loosened, and is almost sure to cut into the wire. For the smaller sizes, a screw and washer connection with upturned lugs on the switch terminal gives a satisfactory contact.

i. Test.

Must operate successfully at 50 per cent overload in amperes and 25 per cent excess voltage, under the most severe conditions with which they are liable to meet in practice.

This test is designed to give a reasonable margin between the ordinary rating of the switch and the breaking-down point, thus securing a switch which can always safely handle its normal load. Moreover, there is enough leeway so that a moderate amount of overloading would not injure the switch.

j. Marking.

Must be plainly marked where it will be visible, when the switch is installed, with the name of the maker and the current and the voltage for which the switch is designed.

Triple pole switches designed with 125 volt spacings, between adjacent blades, should be marked 125 volts, and may be used on D. C. 3-wire systems having 125 volts between adjacent wires and 250 volts between the two outside wires.

k. Spacings.

Spacings must be at least as great as those given in the following table:—

over 125 volts D. C. and A. C.
For Switchboards and Panel Boards:—

	Minimum separation of nearest metal parts of opposite polarity.	Minimum break-distance.
10 amperes	¾ inch	½ inch
30 amperes	1 inch	¾ inch
60 amperes	1¼ inch	1 inch

The 10-ampere switch must have ample metal for stiff-, and to prevent rise in temperature of any part of more 50 degrees Fahrenheit (28 degrees Centigrade) when ying 30 amperes, the contacts being arranged so that a oughly good bearing at every point is obtained with con- surface advised for pure copper blades of about 0.4 square

over 125 volts D. C. and A. C.
For Individual Switches:—

amperes	1¼ inch	1 inch
and 100 amperes	1½ inch	1¼ inch
and 300 amperes	2¼ inch	2 inch
and 600 amperes	2¾ inch	2½ inch
and 1,000 amperes	3 inch	2¾ inch

The 300-ampere switch must not be equipped with cut-out inals.

volts only D. C. and A. C.
For all switches.

amperes	1¾ inch	1½ inch

over 250 volts D. C.
over 500 volts A. C.
For all switches:—

60 and 100 amperes	2¼ inch	2 inch
and 300 amperes	2½ inch	2¼ inch
and 600 amperes	2¾ inch	2½ inch
and 1,000 amperes	3 inch	2¾ inch

The above switches must be stamped "250 V. D. C., 500 A. C"

The 30-ampere switch must have ample metal to prevent rise in temperature of any part of more than 50 degrees Fahrenheit (28 degrees Centigrade) when carrying 60 amperes, the contacts being arranged so that a thoroughly good bearing at every point is obtained with contact surfaces advised for pure copper blades of about 0.8 square inch.

The 300-ampere switch must not be equipped with cut-out terminals.

Cut-out terminals on switches for over 250 volts must be designed and spaced for 600 volt fuses, and in such cases the switches must be stamped "500 V. A. C."

Not over 600 volts D. C. and A. C.

For all switches:—

30 and 60 amperes	4 inch	3½ inch
100 amperes	4½ inch	4 inch

The 30-ampere switch must have ample metal to prevent rise in temperature of any part of more than 50 degrees Fahrenheit (28 degrees Centigrade) when carrying 60 amperes, the contacts being arranged so that a thoroughly good bearing at every point is obtained with contact surfaces advised for pure copper blades of about 0.8 square inch.

Auxiliary breaks or the equivalent are recommended for D. C. switches designed for over 250 volts, and must be provided on D. C. switches designed for use in breaking currents greater than 100 amperes at a voltage of over 250.

For three-wire direct current and three-wire single phase systems the separations and break distances for plain three-pole knife switches must not be less than those required in the above table for switches designed for the voltage between the neutral and outside wires.

Snap Switches.

(See Figures 188 and 189.)

Flush, push-button, door, fixture and other snap switches used on constant-potential systems, must be constructed in accordance with the following specifications.

l. **Base.**

Current-carrying parts must be mounted on non-combustible, non-absorptive, insulating bases, such as slate or

o. **Classification.**

Must be classified as regards both current and voltage as given in the following table, and must be so designed that the bases of one class cannot be used with fuses of another class rated for a higher current or voltage.

Standard Plug or Cartridge Cut-Outs.

Not over 250 Volts:	*Not over 600 Volts:*
0- 30 amperes.	0- 30 amperes.
31- 60 amperes.	31- 60 amperes.
61-100 amperes.	61-100 amperes.
101-200 amperes.	101-200 amperes.
201-400 amperes.	201-400 amperes.
401-600 amperes.	

Sealable Service and Meter Cut-Outs.

Not over 250 Volts:	*Not over 600 Volts:*
0- 30 amperes.	0- 30 amperes.
31- 60 amperes.	31- 60 amperes.
61-100 amperes.	61-100 amperes.
101-200 amperes.	101-200 amperes.

p. **Design.**

Must be of such a design that it will not be easy to form accidental short circuits across live metal parts of opposite polarity on the block or on the fuses in the block.

68. Fuses.

(For installation rules, see Nos. 19 and 23.)

Link Fuses.

(See Figure 194.)

a. **Terminals.**

Must have contact surfaces or tips of harder metal, having perfect electrical connections with the fusible part of the strip.

The use of the hard metal tip is to afford a strong mechanical bearing for the screws, clamps or other devices provided for holding the fuse.

p. Binding Posts.

Binding posts must be substantially made, and the screws must be of such size that the threads will not strip when set up tight.

A set-screw is likely to become loosened, and is almost sure to cut into the wire. A binding screw under the head of which the wire may be clamped and a terminal plate provided with upturned lugs or some other equivalent arrangement, afford reliable contact. Switches with the set-screw form of contact will not be approved.

q. Covers.

Covers made of conducting material, except face plates for flush switches, must be lined on sides and top with insulating, tough and tenacious material at least one thirty-second inch in thickness, firmly secured so that it will not fall out with ordinary handling. The side lining must extend slightly beyond the lower edge of the cover.

Figure 189.

r. Handle or Button.

The handle or button or any exposed parts must not be in electrical connection with the circuit.

s. Test.

Must "make" and "break" with a quick snap, and must not stop when motion has once been imparted by the button or handle.

possible to put any fuse of a given class into a cut-out block which is designed for a current or voltage lower than that of the class to which the fuse belongs.

f. Terminals.

The fuse terminals must be sufficiently heavy to insure mechanical strength and rigidity. The styles of terminals, except for use in sealable service and meter cut-outs, must be as follows:—

Not over 250 Volts:

0-30 Amps.	*A.* Cartridge fuse (ferrule contact). *B.* Approved plugs for Edison cut-outs not exceeding 125 volts, but including 3-wire circuits with grounded neutral and 250 volts between outside wires.
31-60 Amps.	Cartridge fuse (ferrule contact).
61-100 Amps. 101-200 Amps. 201-400 Amps. 401-600 Amps.	Cartridge fuse (knife blade contact).

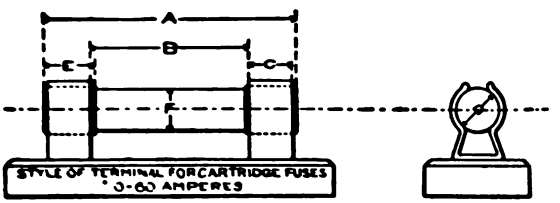
Not over 600 Volts:

0 30 Amps. 31-60 Amps.	Cartridge fuse (ferrule contact).
61-100 Amps. 101-200 Amps. 201-400 Amps.	Cartridge fuse (knife blade contact).

g. Dimensions.

Cartridge enclosed fuses and corresponding cut-out blocks, except for sealable service and meter cut-outs, must conform to the dimensions given in the table attached.

TABLE OF DIMENSIONS OF THE STANDARD CARTRIDGE



Form 1. CARTRIDGE FUSE—Ferrule Contact.

Voltage.	Rated Capacity. Amperes.		A Length over Terminals. Inches.	B Distance between Contact Clips Inches.	C Width of Contact Clips. Inches.
Not over 250	0-30	Form 1	2	1	½
	31-60		3	1¾	⅝
	61-100	Form 2	5⅞	4	⅞
	101-200		7⅛	4½	1¼
	201-400		8⅝	5	1⅝
	401-600		10⅝	6	2⅛
Not over 600	0-30	Form 1	5	4	½
	31-60		5½	4¼	⅝
	61-100	Form 2	7⅞	6	⅞
	101-200		9⅝	7	1¼
	201-400		11⅝	8	1¾

central point of distribution so that one circuit operates to each room on the floor, or to each bay, if the building is of factory type.

By the use of this panelboard with wiring of this character one or all of the circuits can be connected together through one meter.

The panelboard shown in Figure 196 is designed for six meters, while the panelboard shown in Figure 197 is designed for twelve meters. The meter loops are fused on one polarity for the 2-wire meter, and on both polarities for the 3-wire type meter. The common neutral or pressure wire loops from meter to meter, without fusing.

The 2-wire branch circuits are protected in the usual manner by two fuses. One main bus bar runs the full length of the panelboard adjacent to the fuse plug holders on either side of the board. To this bus bar one set of fuses are connected. The other, or adjacent set of fuses are connected to the numbered posts which, in turn, support the round circuit bars crossing the meter bars. The round circuit bar which crosses the meter bar contains a movable switch contactor. This movable switch contactor can be electrically connected to the meter bars at every point the round circuit bar crosses the meter bars. This permits the grouping of circuits in any combination to selected meter bars and through the desired meter.

The meter bus bars are placed on edge for the purpose of condensing the panelboard as much as possible, and also for the purpose of providing a switch blade surface for the movable contactor to engage with.

The meter bars are carried to proper terminal lugs at the top of the board for meter loop connections.

By carefully tracing out the circuit connections in Figure 197 it will be noted that circuits 1, 2 and 3 which operate to rooms 1, 2 and 11 are connected to meter "B."

h Rating.

Fuses must be so constructed that with the surrounding atmosphere at a temperature of 75 degrees Fahrenheit (24 degrees Centigrade) they will carry indefinitely a current 10 per cent greater than that at which they are rated, and at a current 25 per cent greater than the rating, they will open the circuit without reaching a temperature which will injure the fuse tube or terminals of the fuse block. With a current 50 per cent greater than the rating and at room temperature of 75 degrees Fahrenheit (24 degrees Centigrade), the fuses starting cold, must blow within the time specified below:—

0-30 Amperes	1 minute
31-60 Amperes	2 minutes
61-100 Amperes	4 minutes
101-200 Amperes	6 minutes
201-400 Amperes	12 minutes
401-600 Amperes	15 minutes

i. Marking.

Must be marked, where it will be plainly visible, with the name or trade-mark of the maker, the voltage and current for which the fuse is designed, and the words "National Electrical Code Standard." Each fuse must have a label, the color of which must be green for 250-volt fuses and red for 600-volt fuses.

It will be satisfactory to abbreviate the above designation to "N. E. Code St'd" where space is necessarily limited.

j. Temperature Rise.

The temperature of the exterior of the fuse enclosure must not rise more than 125 degrees Fahrenheit (70 degrees Centigrade) above that of the surrounding air when the fuse is carrying the current for which it is rated.

k. Test.

Must not hold an arc or throw out melted metal or sufficient flame to ignite easily inflammable material on or near the cut-out when only one fuse is blown at a time on a short circuit on a system of the voltage for which the fuse is rated.

Circuits 5 and 6 operating to rooms 3 and 13 are connected to meter "C."

Circuits 4, 12 and 18 operating to rooms 12, 16 and 19 are connected to meter "E."

The preceding three meters are of the 2-wire type.

Circuits 8, 15, 16, 10, 13 and 14 operating to rooms, 14, 8, 18, 15, 7 and 17 are connected to Meter F-G. This is a 3-wire type meter.

Figure 198.

This panelboard occupies a very small amount of space and all wire connections are made permanently on the face of the panelboard. This prevents improper meter connections and enables the tenant to readily trace the circuits connected to his meter.

This type of panelboard can be used to advantage for metering current owing to the fact that repeated changes in connection of the circuit wires to meters can be made without the use of loose wiring connections and the consequent fire hazard.

70. Cabinets.

(See Figure 198.)

For panel and distributing boards, cut-outs and switches.

(For installation rule see Nos. 8 d, 19 b-d, 23 c and 24 b.)

a. Design.

Must in all cases be so constructed as to insure ample strength and rigidity and be dust tight.

The hard usage to which cabinets are often subjected, especially during process of installation, makes it necessary so to construct them that they will be strong enough to keep their shape, thus permitting doors to close tightly and making possible the proper installation of wiring and conduit.

When doors are of metal, and less than 0.109 inch (No. 12 U. S. gage) in thickness and are not lined with insulating material there must be a space of at least one inch between the door and an enclosed fuse or any live metal part. A space of at least two inches must be provided between open-link fuses and metal, metal-lined or glass paneled doors of cabinets. Except as above specified there must be a space of at least one-half inch between the walls, back or door of any cabinet and any exposed live metal part. Cabinets must be deep enough to allow the door to be closed when switches rated at 30 amperes or less are in any position, and when larger switches are thrown open as far as their construction or installation will permit.

There must be a space of at least one-half inch between the walls and back of any cabinet and the nearest exposed current-carrying part.

b. Material.

May be either of cast or sheet metal, wood or approved composition. Wooden or composition cabinets must not be used on metal conduit, armored cable or metal moulding systems.

All metal used in construction of cabinets including linings, if any, must be thoroughly painted or otherwise treated to prevent corrosion.

c. Wooden Cabinets.

Wood must be well seasoned and at least three-fourths inch thick and be thoroughly filled and painted, and must be lined with a non-combustible material.

d. Linings.

In all cabinets, linings of slate, marble or approved composition must be at least one-fourth inch thick and firmly secured in place; when metal is used for the lining it must be at least No. 16 U. S. gage in thickness. For lining wooden

Figure 199.

cabinets one-eighth inch rigid asbestos board may be used when firmly secured in place by screws or tacks.

e. Composition Cabinets.

Only approved material should be used. and in no case less than three-fourths of an inch in thickness.

f. Metal Cabinets.

If cast metal is used a thickness of at least one-eighth inch must be provided. Sheet metal must not be less than

of the circuit, must not be sufficiently exposed to to be brought in contact with anything outside c and socket.

j. **Base.**

The base on which current carrying parts a must be of porcelain and all insulating material u: of approved material.

k. **Key.**

The socket key-handle must be of such a mat will not soften from the heat of a fifty candle- hanging downwards from the socket in air at Fahrenheit (21 degrees Centigrade), and must but not necessarily rigidly, attached to the m which it is designed to turn.

l. **Sealing.**

All screws in porcelain pieces, which can be fi in place, must be so sealed by a waterproof comp will not melt below 200 degrees Fahrenheit (93 de grade).

m. **Putting Together.**

The socket as a whole must be so put together not rattle to pieces. Bayonet joints or an equival ommended.

n. **Test.**

The socket when slowly turned "on and off" at to exceed ten times per minute, while carrying a ampere at 250 volts, must "make" and "break" 6,000 times before failing and must operate succes per cent overload in amperes at both 125 and 250 current under the most severe conditions which the to meet in practice.

o. **Keyless Sockets.**

Keyless sockets of all kinds must comply w quirements for key sockets as far as they apply.

p. **Sockets of Insulating Material.**

Sockets made of porcelain or other insulating material must conform to the above requirements as far as they apply, and all parts must be strong enough to withstand a moderate amount of hard usage without breaking.

Porcelain shell sockets being subject to breakage, and constituting a hazard when broken, will not be accepted for use in places where they would be exposed to hard usage.

q. **Inlet Bushing.**

When the socket is not attached to a fixture, the threaded inlet must be provided with a strong insulating bushing having a *smooth* hole at least nine thirty-seconds of an inch in diameter. The edges of the bushing must be rounded

Figure 201.

and all inside fins removed, so that in no place will the cord be subjected to the cutting or wearing action of a sharp edge.

Bushings for sockets having an outlet threaded for three-eighths-inch pipe should have a hole thirteen thirty-seconds of an inch in diameter, so that they will accommodate *approved* reinforced flexible cord.

73. Hanger-Boards for Series Arc Lamps.

(See Figure 201.)

(For installation rules see Nos. 21 d and 22 b.)

a. Hanger-boards must be so constructed that all wires and current-carrying devices thereon will be exposed to view and thoroughly insulated by being mounted on a non-combustible, non-absorptive, insulating substance. All switches attached to the same must be so constructed that they shall be automatic in their action, cutting off both poles to the lamp, not stopping between points when started and preventing an arc between points under all circumstances.

74. Arc Lamps.

(See Figure 202.)

(For installation rules see Nos. 21 and 33.)

a. Must be provided with reliable stops to prevent ca
bons from falling out in case the clamps become loose.

b. All exposed parts must be carefully insulated fro
the circuit.

Figure 202.

c. Must, for constant-current systems, be provided with
approved hand switch, and an automatic switch that
shunt the current around the carbons, should they fail to f
properly

The hand switch to be approved, if placed anywhere
cept on the lamp itself, must comply with requirements
switches on hanger-boards as laid down in No. 73.

d. Terminals must be designed to secure a thorou
good and permanent contact with the supply wires, w
contact must not become loosened by motion of the l
during trimming.

5. Spark Arresters.

(See Figure 202.)

(For installation rules see Nos. 21 c and 33 c.)

a. Spark arresters must so close the upper orifice of the globe that it will be impossible for any sparks, thrown off by the carbons, to escape.

6. Insulating Joints.

(For installation rules, see No. 30 a.)

a. Must be entirely made of material that will resist the action of illuminating gases and will not give way or soften under the heat of an ordinary gas flame or leak under a moderate pressure. Must be so arranged that a deposit of moisture will not destroy the insulating effect; must show a dielectric strength between gas-pipe attachments sufficient to resist throughout five minutes the application of an electro-motive force of 4,000 volts; and must be sufficiently strong to resist the strain to which they are liable to be subjected during installation.

Insulating joints having soft rubber in their construction will not be approved.

7. Fixtures.

(For installation rules, see Nos, 24 e, and 26 v to y. For construction of Wires, see No. 55.)

a. Material.

Must be of metal or hard wood, except that other approved material may be used if re-enforced by metal or otherwise constructed to secure requisite mechanical strength.

In all cases mechanical strength must be secured practically equivalent to an all-metal fixture of similar size and form.

b. Assembly.

All arms must be reliably secured to prevent turning. Arms of threaded tubing must not be lighter than No. 18 B. & S. gage, and with screw joints of arms there must be not less than five threads all engaging. All methods of fastening arms

or making joints between metal parts by soldering, brazing or otherwise, must be such as to secure in every case ample strength and reliability.

c. **Sockets.**

Must, except on pendant cords, be attached to the metal of the fixtures and must be secured in a reliable and permanent manner.

Receptacles having exposed terminals must not be used in canopies or in any part of fixtures unless completely enclosed in metal.

d. **Wireways.**

All burrs, fins and sharp edges liable to injure wire coverings must, where practicable, be removed or rounded, but in every case it must be possible to pull in and also to withdraw the wires without injuring them. Where supply wires enter fixture stems or casings there must be suitable fittings having smooth rounded edges to prevent injury to the wire coverings.

In non-metallic fixtures wireways must be metal-lined unless approved armored conductors with suitable fittings are used.

On chains or similar parts where conductors are not completely enclosed in metal, wires must be stranded and must have rubber insulation not less than one thirty-second inch in thickness or approved pendant or portable cord may be used.

e. **Markings.**

Must be marked with the manufacturer's name or trade-mark.

f. **Test.**

Must be tested in an approved manner for short circuits between conductors and for contacts between conductors and metal parts of fixtures.

78. Rheostats, Resistance Boxes and Equalizers.

(For installation rules, see Nos. 4 a and 8 c.)

a. **Materials.**

Must be made entirely of non-combustible materials, except such minor parts as handles, magnet insulation, etc. All sep-

nents, lever arms, etc., must be mounted on non-combustible, on-absorptive, insulating material.

Rheostats used in dusty or linty places or where exposed to flyngs of combustible material, must be so constructed that even the resistive conductor be fused by excessive current, the arc r any attendant flame will be quickly and safely extinguished. heostats used in places where the above conditions do not exist ıay be of any approved type.

Wood or other suitable material may be used for parts of the ısings or covers of drum controllers, providing these parts are roperly lined or treated with fire-resisting materials, and so arınged that should the combustible parts within the casing be igıited, the fire would be confined within the casing or cover.

In drum controllers and apparatus of like nature where the con'olling mechanism is entirely enclosed in a substantial tight metal ıse or compartment, hard wood or other suitable material may be sed for bases for mounting current-carrying parts, or for other arts which cannot readily be made of non-combustible material, rovided such combustible material is present only in such amount nd so disposed that, even if it be totally destroyed by fire or exssive heat, the effect shall be confined to the interior of the case.

Construction.

Must be so constructed that when mounted on a plane surace the casing will make contact with such surface only at the oints of support. An air space of at least one-fourth inch etween the rheostat casing and the supporting surface will be equired.

The construction throughout must be heavy, rugged and ıoroughly workmanlike.

Connections.

Clamps for connecting wires to the terminals must be of a esign which will insure a thoroughly good connection, and ıust be sufficiently strong and heavy to withstand consideble hard usage. For currents above fifty amperes, lugs firmly crewed or bolted to the terminals, and into which the connectıg wires shall be soldered, must be used.

Clamps or lugs will not be required when leads designed for ıldered connections are provided.

Marking.

Must be plainly marked, where it may be readily seen after ıe device is installed, with the rating and the name of the ıaker; and the terminals of motor-starting rheostats must be ıarked to indicate to what part of the circuit each is to be ɔnnected, as "line," "armature" and "field."

e. Contacts.

The design of the fixed and movable contacts and the resistance in each section must be such as to secure the least tendency toward arcing and roughening of the contacts, even with careless handling or the presence of dirt.

In motor-starting rheostats, the contact at which the circuit is broken by the lever arm when moving from the running to the starting position, must be so designed that there will be no detrimental arcing. The final contact, if any, on which the arm is brought to rest in the starting position must have no electrical connection.

Experience has shown that sharp edges and segments of thin material help to maintain an arc, and it is recommended that these be avoided. Segments of heavy construction have a considerable cooling effect on the arc, and rounded corners tend to spread it out and thus dissipate it.

It is recommended that the circuit-breaking contacts be so constructed as to "break" with a quick snap, independently of the slowness of movement of the operator's hand, or that a magnetic blowout or equivalent device be used. For dial type rheostats the movable contact should be flexible in a plane at right angles to the plane of its movement, and for medium and larger sizes the stationary contacts should be readily renewable.

f. No-Voltage Release.

Motor-starting rheostats must be so designed that the contact arm cannot be left on intermediate segments, and for direct current circuits must be provided with an automatic device which will interrupt the supply circuit before the speed of the motor falls to less than one-third of its normal value. In motor starting rheostats for alternating current circuits the automatic interrupting device may be omitted.

g. Overload Release.

Overload release devices which are inoperative during the process of starting a motor will not be approved, unless other circuit-breakers or fuses are installed in connection with them.

If, for instance, the over-load release device simply releases the starting arm and allows it to fly back and break the circuit, it is inoperative while the arm is being moved from the starting to the running position.

h. Test.

Must, after 100 operations under the most severe normal conditions for which the device is designed, show no serious

ing of the contacts or other faults, and the release mechan-
of motor-starting rheostats must not be impaired by such
t.
ield rheostats, or main-line regulators intended for con-
ous use, must not be burned out or depreciated by carry-
he full normal current on any step for an indefinite period.
stances intended for intermittent use (such as on electric
es, elevators, etc.) must be able to carry their rated cur-
on any step for as long a time as the character of the
ratus which they control will permit them to be used con-
ously.
tarting duty resistances shall either be so constructed that
e resistance conductor be fused the arc, or any attendant
e or molten droppings, shall be confined within the rheo-
or they shall be constructed with such capacity that when
rated full-load current is passed through the entire re-
nce for a period of five minutes there shall be no result-
flaming, or molten droppings.
Continuous duty resistances shall either be so constructed
if the resistive conductor be fused the arc or any at-
ant flame or molten droppings shall be confined within the
stat or they shall be constructed with such capacity that
ubjected to a current flow throughout the entire rheostat,
er cent in excess of that at which they are rated, for a
od of two hours, there shall be no resultant flaming or
en droppings.

Auto-Starters.

(For installation rules see No. 8 d.)

*struction and Test of Auto-starters Ranging to a Maxi-
um of 100 Horse Power and 3,500 Volts.*

Under this class are included all such devices for starting
C. Motors as employ transformer windings whereby the
ntial impressed upon the motor terminals during process
tarting may be made less than the full line voltage and
h have switching devices for accomplishing this result.
pparatus designed for starting A. C. Motors by employ-
ohmic resistance coils are to be judged under No. 78—
ostats.

a. Construction.

Coils and switches of auto-starters used in dusty and linty places or where exposed to flyings of combustible material, must be completely enclosed in substantial metal cases so constructed as to effectually exclude ordinary dust, lint or flyings of combustible material.

Auto-starters used in places where the above conditions do not exist, may be of any approved type.

Cases for either transformer coils or switches must provide for access to the interior for inspection and for renewal of oil, and must be so constructed that when mounted on a plain surface the casing will make contact with such surface only at points of support. An air space at least one-fourth of an inch between the casing and supporting surface will be required.

The oil tank shall be marked in a suitable manner to indicate the proper oil level.

The switch must provide an off position, or running position and at least one starting position. It must be so arranged that it will be held in off and running positions but cannot be left in a starting position or without the proper running overload protective devices in the circuit.

The construction throughout must be thoroughly substantial.

b. Connections.

Clamps for connecting wires to the terminal board must be of a design which will insure a thoroughly good connection and must be sufficiently strong and heavy to withstand considerable hard usage. For currents above 50 amperes, lugs firmly screwed or bolted to the terminal boards, and into which the connecting wires shall be soldered, must be used. Clamps or lugs will not be required when leads designed for soldered connections are provided.

c. Marking.

Must be plainly marked, where it may be readily seen after the device is installed, with the rating and name of the maker; terminals to be so marked as to indicate to what part of the circuit each is to be connected.

d. **Insulation Test.**

The insulation of the completely assembled apparatus must withstand for one minute a potential test between live metal parts and frame core and case as follows:—

Rated Terminal Voltage of Circuit.	Testing Voltage.
Not exceeding 400 volts	1,500 volts
401-800	2,000 volts
801-1,200	3,500 volts
1,201-2,500	5,000 volts
2,500 up	Double normal rated Voltages

e. **Tests.**

With full line voltage applied to line terminals and current taken from taps giving between 40 and 60 per cent of the normal line voltage, 300 per cent of full load current of the motor applied for the first fifteen seconds of each four-minute period for one hour must show no resultant flaming or molten droppings. The oil, if any, in which the transformer windings are immersed shall not overflow the containing case and the entire starter shall be practically uninjured.

80. Reactive Coils and Condensers.

a. Reactive coils must be made of non-combustible material, mounted on non-combustible bases and treated, in general, as sources of heat.

b. Condensers must be treated like other apparatus operating with equivalent voltage and currents. They must have non-combustible cases and supports, and must be isolated from all combustible materials and, in general, treated as sources of heat.

81. Transformers.

(For installation rules see Nos. 11, 14, 15, 36 and 45.)

a. Must not be placed in any but metallic or other non-combustible cases.

It is advised that every transformer with either primary or secondary voltages over 550 volts to be so designed and connected that the middle point of the secondary coil can be reached, if, at any future time, it should be desired to ground it.

b. Must be plainly marked where it may be readily seen after the transformer is installed, with the name of the maker, with the primary and secondary voltages and the rated capacity.

c. Must be constructed to comply with the following tests:—

1. Shall be run for a sufficient time to reach a practically constant temperature at full rated load, and at the end of that time a rise in temperature, as measured by the increase in resistance of the windings, shall not exceed 50 degrees Centigrade (122 degrees Fahrenheit).
2. When heated to normal full load operating temperature, the insulation of transformers shall withstand continuously for one minute a difference of potential (alternating) between primary and secondary coils and between the primary coils and the core according to the following table:—

Primary or Secondary

Voltage.	Test Voltage.
Not exceeding 400 volts	1,500
From 400 to 550 volts	2,000
Over 550 volts	To follow the standardization rules of the American Institute of Electrical Engineers.

82. Lightning Arresters.

(For installation rules, see No. 5.)

a. Lightning arresters must be of *approved* construction. (See list of Electrical Fittings.)

83. Electric Signs (for Low-Potential Systems only).

(For installation rules, see No. 23 d.)

a. Material.

Must be constructed entirely of metal or other approved non-combustible material except that wood may be used on outside for decoration if kept at least two inches from nearest lamp receptacles.

Sheet metal must be not less than No. 28 U. S. metal gage. All metal must be galvanized, enameled or treated with at least three coats of anti-corrosive paint, or otherwise protected in an approved manner against corrosion.

). Construction.

Must be so constructed as to secure ample strength and rigidity.

Must be so constructed as to be practically weatherproof and so as to enclose all terminals and wiring other than the supply leads, except that open work will be permitted for signs on roofs or open ground where not subject to mechanical injury, provided the wiring is in accordance with Section "e" below.

Cut-outs, transformers, unless of weatherproof type, flashers and other similar devices on or within the sign structure, must be in a separate, completely enclosed, accessible and weatherproof compartment, or, in a substantial weatherproof box or cabinet of metal of thickness not less than that of the metal of the sign itself.

Each compartment must have suitable provision for drainage through one or more holes each not less than one-quarter inch in diameter.

:. Marking.

Must have the maker's name or trademark permanently attached to the exterior.

***l.* Receptacles.**

Must be so designed as to afford permanent and reliable means to prevent possible turning; must be so designed and placed that terminals will be at least one-half inch from other terminals and from metal of the sign except that where open work is permitted, this separation must be one inch.

Miniature receptacles will not be approved for use in outdoor signs.

:. Wiring.

Must be approved rubber covered, not less than No. 14 B. and S. gage, and, except where open work is permitted, must be double braided.

Must be neatly run, and so disposed and fastened as to be mechanically secure.

Must be soldered to terminals, and exposed parts of wires and terminals must be treated to prevent corrosion.

Must, where they pass through walls or partitions of the sign, be protected by approved bushings.

On outside of sign structure, except where open work is permitted, must be in approved metal conduit or in approved armored cable.

For open work, wire must be rigidly supported on non-combustible, non-absorptive insulators, which separate the wires at least one inch from the surface wired over. Rigid supporting requires, under ordinary conditions where wiring over flat surfaces, supports at least every four and one-half feet. If the wires are liable to be disturbed, the distances between supports should be shortened. In those parts of circuits where wires are connected to approved receptacles which hold them at least one inch from surface wired over, and which are placed not over one foot apart, such receptacles will be considered to afford the necessary support and spacing of the wires. Between receptacles more than one foot, but less than two feet apart, an additional non-combustible, non-absorptive insulator maintaining a separation and spacing equivalent to the receptacles must be used. Except as above specified, wires must be kept apart at least two and one-half inches for voltages up to 300, and four inches for higher voltages.

f. Leads from sign must pass through the walls of sign either through approved metal conduit or armored cable, or must be neatly cabled and pass through one or more approved non-combustible, non-absorptive bushings.

g. Not over 1,320 watts shall be dependent upon final cut-out.

SIGN HANGING.

The N. E. Code recognizes none but signs made entirely of metal, nevertheless there are at the present time many signs of wood construction installed and in Figure 203 such a sign is shown. In the hanging of these old wooden signs certain

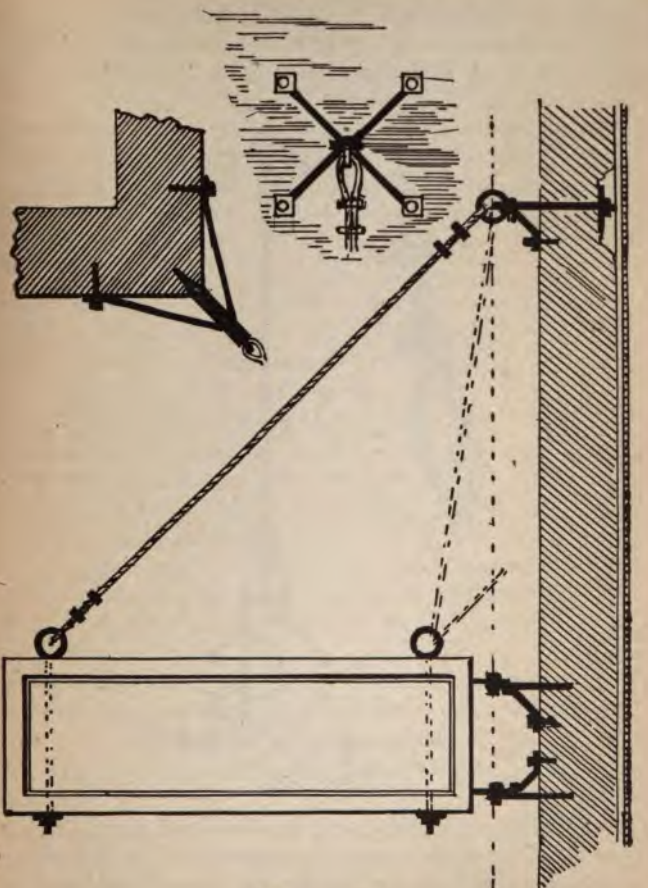


Figure 203.

precautions are necessary that are not called for in connection with metallic signs. The framework of a wood sign is generally made up as indicated in Figure 204 and where the

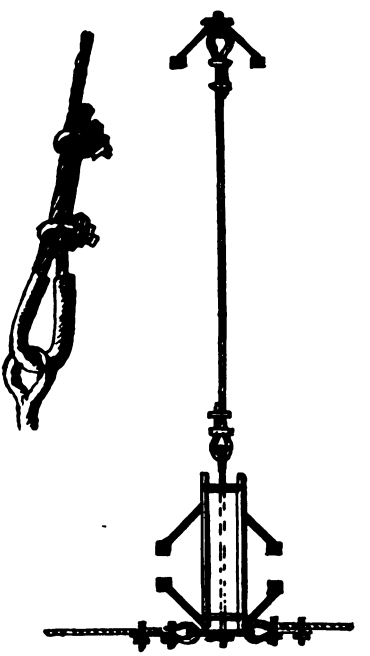


Figure 204.

top and side pieces come together the wood soon begins to decay sufficiently to weaken the structure. For this reason the cross pieces on the supporting bolts should be long enough to catch the outside boards of sign as these carry the

etters and make up nearly the whole weight of the sign. The nanner of supporting the rear end of sign is also open to ;erious objections and if the sign is at all heavy it is ad-isable to provide an extra bolt at rear and attach this to an xtra cable as shown by broken lines, Figure 203.

If signs are required to swing as they are in many cities t will be necessary to arrange the turning points at top end)f cable to be perpendicularly above the turning points at ;ign otherwise the sign will not swing level.

Wherever possible signs should be supported by bolts)assing through brick or stone walls. The fronts of such walls are not always of the best and usually consist of ve-neering which is merely stuck on and quite flimsy.

In Figure 205 is shown the cross-section of an expansion)olt which has shown itself to be very serviceable. It is made)f the shape shown, the black portion representing a lead ;leeve which surrounds the bolt. After the bolt is in place the lead is pounded in with a small piece of pipe. The lead thus forced in expands into every crevice in the drill hole thus, not only holding the bolt very tight, but also ex-cluding all water that might cause corrosion or decay. If the brick or stone itself is secure this form of support is very substantial.

The supports to a sign should always be arranged as high above the sign as possible if dependence is to be placed upon expansion bolts. At low angles the pull is almost straight out from the wall while at a high elevation the pull is downward.

The side strain on side guys in a storm is much greater than the weight of the sign imposes upon them in support but of course a side guy giving way, if the sign is arranged to

swing, does not necessarily allow the sign to fall. The wind pressure in heavy storms and at velocities often met with in narrow streets is 30 pounds or more per square foot. This for a sign 10 by 3 feet equals 900 pounds, while a sign of this size would not ordinarily weigh above 300.

The side guys should be spread at least at an angle of 45 degrees and where this is not possible stiff braces should preferably be used on both sides. If such guys are tight there will not only be a pull against the wind but a push also.

Wherever the cables are attached to sign they should be protected by sleeves and clamped together by two clips as

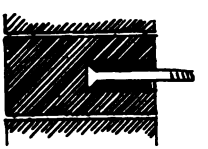


Figure 205.

shown in the figure. Good galvanized cable should be used. A poor cable in the center of a large city will show strong evidence of rusting in less than a year, while a good one will last a very long time. In the outskirts the effect of rust is less marked and most any galvanized cable will last several years.

It is good practice to remove any cable that shows the slightest evidence of rusting. In the early days of electric sign hanging quite frequently old elevator cables were used for that purpose. Several of these rusted fast enough to part in less than a year.

blank for future use.

CLASS E.

MISCELLANEOUS.

85. Signaling Systems.

Governing wiring for telephone, telegraph (except wireless telegraph apparatus), district messenger and call-bell circuits, fire and burglar alarms, and all similar systems which are hazardous only because of their liability to become crossed with electric light, heat or power circuits.

a. Outside wires should be run in underground ducts or strung on poles, and kept off of the roofs of buildings, except by special permission of the Inspection Department having jurisdiction, and must not be placed on the same cross-arm with electric light or power wires. They should not occupy the same duct, manhole or handhole of conduit systems with electric light or power wires.

Single manholes, or handholes separated into sections by means of partitions of brick or tile will be considered as conforming with the above rule.

The liability of accidental crossing of overhead signaling circuits with electric light and power circuits, may be guarded against to a considerable extent by endeavoring to keep the two classes of circuits on different sides of the same street.

When the entire circuit from Central Station to building is run in underground conduits, Sections b to m inclusive do not apply.

b. When outside wires are run on same pole with electric light or power wires, the distance between the two inside pins of each cross-arm must not be less than twenty-four inches.

Signaling wires being smaller and more liable to break and fall, should generally be placed on the lower cross-arms.

When the wires are carried in approved cables, the next three sections (c, d and e) do not apply.

c. Where wires are attached to the outside walls of buildings, they must have an *approved* rubber insulating covering,

and on frame buildings or frame portions of other buildings shall be supported on glass or porcelain insulators, or knobs.

d. The wires from last outside support to the cut-outs or protectors must be of copper, and must have an *approved* rubber insulation. Must be provided with drip loops immediately outside the building and at entrance.

e. Wires must enter building through approved non-combustible, non-absorptive, insulating bushings sloping upward from the outside.

Installations where the Current-carrying Parts of the Apparatus Installed are Capable of Carrying Indefinitely a Current of Ten Amperes.

f. An all-metallic circuit shall be provided, except in telegraph systems.

g. At the entrance of wires to building, *approved* single pole cut-outs, designed for 251-600 volts potential and containing fuses rated at not over ten amperes capacity, shall be provided for each wire. These cut-outs must not be placed in the immediate vicinity of easily ignitible stuff, or where exposed to inflammable gases, or dust or to flying of combustible material.

h. The wires inside building shall be of copper not less than No. 16, B. & S. gage, and must have insulation and be supported, the same as would be required for an installation of electric light or power wiring, 0-600 volts potential.

i. The instruments shall be mounted on bases constructed of non-combustible, non-absorptive, insulating material. Holes for the supporting screws must be so located or countersunk, that there will be at least one-half inch space, measured over the surface, between the head of the screw and the nearest live metal part.

Installations where the Current-carrying Parts of the Apparatus Installed are Not Capable of Carrying Indefinitely a Current of Ten Amperes.

j. Must be provided with an *approved* protective device located as near as possible to the entrance of wires to building. The protector must not be placed in the immediate vicinity of easily ignitible stuff, or where exposed to inflammable gases or dust or flyings of combustible materials.

k. Wires from entrance to building to protector must be supported on porcelain insulators, so that they will come in contact with nothing except their designed supports.

l. The ground wire of the protective device shall be run in accordance with the following requirements:—

1. Shall be of copper and not smaller than No. 18 B. & S. gage.
2. Must have an insulating covering *approved* for voltages from 0 to 600, except that the preservative compound may be omitted.
3. Must run in as straight a line as possible to a good permanent ground. This may be obtained by connecting to a water or gas pipe connected to the street mains or to a ground rod or pipe driven in permanently damp earth. When connections are made to pipes, preference shall be given to water pipes. If attachment is made to gas pipe, the connection in all cases must be made between the meter and the street mains. In every case the connection shall be made as near as possible to the earth.

When the ground wire is attached to a water pipe or a gas pipe, it may be connected by means of an approved ground clamp fastened to a thoroughly clean portion of said pipe, or the pipe shall be thoroughly cleaned and tinned with rosin flux solder, and the ground wire shall then be wrapped tightly around the pipe and thoroughly soldered to it.

When the ground wire is attached to a ground rod driven into the earth, the ground wire shall be soldered to the rod in a similar manner.

Steam or hot-water pipes must not be used for a protector ground.

m. The protector to be approved must comply with the following requirements:—

For Instrument Circuits of Telegraph Systems.

1. An *approved* single pole cut-out, in each wire, designed for 2,000 volts potential, and containing

fuses rated at not over one ampere capacity. When main line cut-outs are installed as called for in section *g*, the instrument cut-outs may be placed between the switchboard and the instrument as near the switchboard as possible.

r all Other Systems.

1. Must be mounted on non-combustible, non-absorptive, insulating bases, so designed that when the protector is in place, all parts which may be alive will be thoroughly insulated from the wall to which the protector is attached.
2. Must have the following parts:—

A lightning arrester which will operate with a difference of potential between wires of not over 500 volts, and so arranged that the chance of accidental grounding is reduced to a minimum.

A fuse designed to open the circuit in case the wire become crossed with light or power circuits. The fuse must be able to open the circuit without arcing or serious flashing when crossed with any ordinary commercial light or power circuit.

A heat coil, if the sensitiveness of the instrument demands it, which will operate before a sneak current can damage the nstrument the protector is guarding.

Heat coils are necessary in all circuits normally closed through magnet windings, which cannot indefinitely carry a current of at least five amperes.

The heat coil is designed to warm up and melt out with a current large enough to endanger the instruments if continued for a long time, but so small that it would not blow the fuses ordinarily found necessary for such instruments. The smaller currents are often called "sneak" currents.

3. The fuses must be so placed as to protect the arrester and heat coils, and the protector terminals must be plainly marked "line," "instrument," "ground."

An easily read abbreviation of the above words will be allowed.

The Following Rules Apply to All Systems whether the Wires from the Central Office to the Building are Overhead or Underground.

n. Wires beyond the protector, or wires inside buildings where no protector is used, must be neatly arranged and securely fastened in place in some convenient, workmanlike manner.

They must not come nearer than two inches to any electric light or power wire in the building, unless separated therefrom by some continuous and firmly fixed non-conductor creating a permanent separation; this non-conductor to be in addition to the regular insulation on the wire.

The wires would ordinarily be insulated, but the kind of insulation is not specified, as the protector is relied upon to stop all dangerous currents. Porcelain tubing or *approved* flexible tubing may be used for encasing wires where required as above.

o. Wires where bunched together in a vertical run within any building must have a fire-resisting covering sufficient to prevent the wires from carrying fire from floor to floor unless they are run either in non-combustible tubing or in a fireproof shaft, which shaft must be provided with fire stops at each floor.

Signaling wires and electric light or power wires may be run in the same shaft, provided that one of these classes of wires is run in non-combustible tubing, or provided that when run otherwise these two classes of wires shall be separated from each other by at least two inches.

In no case shall signaling wires be run in the same tube with electric light or power wires.

p. Transformers or other devices for supplying current to signaling systems from light, heat or power circuits must be of a design expressly approved for this purpose. The primary wiring must be installed in accordance with the rules for "Class C," and the secondary wiring in accordance with "Class E."

86. Wireless Telegraph Apparatus.

NOTE.—**These rules do not apply to Wireless Telegraph apparatus installed on shipboard.**

In setting up Wireless Telegraph apparatus (so-called) all wiring within the building must conform to the Rules and

Requirements of the National Electrical Code for the class of work installed and the following additional specifications:—

a. Aerial conductors to be permanently and effectively grounded at all times when station is not in operation by a conductor not smaller than No. 4 B. & S. gage copper wire, run in a direct line as possible to water pipe at a point on the street side of all connections to said water pipe within the premises, or to some other equally satisfactory earth connection.

b. Aerial conductors when grounded as above specified must be effectually cut off from all apparatus within the building.

c. Or the aerial to be permanently connected at all times to earth in the manner specified above, through a short-gap lightning arrester; said arrester to have a gap of not over .015 inch between brass or copper plates not less than 2½ inches in length parallel to the gap and 1½ inches the other way with a thickness of not less than one-eighth inch mounted upon non-combustible, non-absorptive, insulating material of such dimensions as to give ample strength. Other approved arresters of equally low resistance and equally substantial construction may be used.

d. In cases where the aerial is grounded as specified in paragraph 1, the switch employed to join the aerial to the ground connection shall not be smaller than a standard 100 ampere knife switch.

e. Where supply is obtained direct from the street service the circuit must be installed in approved metal conduits or armored cable. In order to protect the supply system from high potential surges, there must be inserted in circuit either a transformer having a ratio which will have a potential on the secondary leads not to exceed 550 volts, or two condensers in series across the line, the connection between said condensers to be permanently and effectually grounded. These condensers should have capacity of not less than one-half m. f.

37. Electric Gas Lighting.

a. Electric gas lighting, unless it is the *frictional* system, must not be used on the same fixture with the electric light.

38. Insulation Resistance.

The wiring in any building must test free from grounds;

i. e., the complete installation must have an insulation between conductors and between all conductors and the ground (*not including* attachments, sockets, receptacles, etc.) not less than *that* given in the following table:—

Up to	5 amperes	4,000,000 ohms.
Up to	10 amperes	2,000,000 ohms.
Up to	25 amperes	800,000 ohms.
Up to	50 amperes	400,000 ohms.
Up to	100 amperes	200,000 ohms.
Up to	200 amperes	100,000 ohms.
Up to	400 amperes	50,000 ohms.
Up to	800 amperes	25,000 ohms.
Up to	1,600 amperes	12,500 ohms.

The test must be made with all cut-outs and safety devices in place. If the lamp sockets, receptacles, electroliers, etc., are also connected, only one-half of the resistances specified in the table will be required.

89. Soldering Fluid.

a. The following formula for soldering fluid is suggested:—

Saturated solution of zinc chloride	5 parts
Alcohol	4 parts
Glycerine	1 part

CLASS F.

MARINE WORK.

Generators.

. Must be located in a dry place.
. Must have their frames insulated from their bed-plates.
Must each be provided with a waterproof cover.
. Must each be provided with a name-plate, giving the
er's name, the capacity in volts and amperes, and the nor-
speed in revolutions per minute.

Wires.

. Must be supported in *approved* moulding or conduit,
pt at switchboards and for portables.

ecial permission may be given for deviation from this rule
namo-rooms.

. Must have no single wire larger than No. 12 B. & S.
. Wires to be stranded when greater carrying capacity
quired. No single solid wire smaller than No. 14 B. &
age, except in fixture wiring to be used.

tranded wires must be soldered before being fastened un-
clamps or binding screws, and when they have con-
ivity greater than that of No. 8 B. & S. gage copper wire
must be soldered into lugs.

. Splices or taps in conductors must be avoided as far
ossible. Where it is necessary to make them they must
) spliced or joined as to be both mechanically and electric-
secure without solder. They must then be soldered, to
re preservation, covered with an insulating compound
l to the insulation of the wire, and further protected by a
rproof tape. The joint must then be coated or painted
a waterproof compound.

ll joints must be soldered unless made with some form of
oved splicing device.

For Moulding Work.

d. Must have an *approved* insulating covering at least three thirty-seconds of an inch in thickness and be covered with a substantial waterproof braid.

The physical characteristics shall not be affected by any change in temperature up to 200 degrees Fahrenheit (93 degrees Centigrade). After two weeks' submersion in salt water at 70 degrees Fahrenheit (21 degrees Centigrade), it must show an insulation resistance of 100 megohms per mile after three minutes' electrification with 550 volts.

e. Must have, when passing through water-tight bulkheads and through all decks, a metallic stuffing tube lined with hard rubber. In case of deck tubes, they must be boxed near deck to prevent mechanical injury.

f. Must be bushed with hard rubber tubing, one-eighth of an inch in thickness, when passing through beams and non-water-tight bulkheads.

For Conduit Work.

g. Must have an *approved* insulating covering.

The insulation for conductors, for use in lined conduits, to be approved, must be at least three thirty-seconds of an inch in thickness and be covered with a substantial waterproof braid. The physical characteristics shall not be affected by any change in temperature up to 200 degrees Fahrenheit (93 degrees Centigrade).

After two weeks' submersion in salt water at 70 degrees Fahrenheit (21 degrees Centigrade), it must show an insulation resistance of 100 megohms per mile after three minutes' electrification with 550 volts.

For unlined metal conduits, conductors must conform to the specifications given for lined conduits, and in addition have a second outer fibrous covering at least one thirty-second of an inch in thickness and sufficiently tenacious to withstand the abrasion of being hauled through the metal conduit.

h. Must not be drawn in until the mechanical work on the conduit is completed and same is in place.

i. Where run through coal bunkers, boiler rooms, and where they are exposed to severe mechanical injury, must be encased in *approved* conduit.

j. Must, for alternating systems, have the two or more wires of a circuit drawn in the same conduit.

The same conduit must not contain more than four two-wire, or three three-wire circuits of the same system, except by special permission of the Inspection Department having jurisdiction, and must never contain circuits of different systems.

It is suggested that this be done for direct current systems also, so that they may be changed to alternating systems at any time, induction troubles preventing such a change if the wires are in separate conduits.

92. Portable Conductors.

a. Must be made of two stranded conductors each having a carrying capacity equivalent to not less than No. 14 B. and S. gage, and each covered with an *approved* insulation and covering.

Where not exposed to moisture or severe mechanical injury, each stranded conductor must have a solid insulation at least one thirty-second of an inch in thickness, and must show an insulation resistance between conductors, and between either conductor and the ground, of at least fifty megohms per mile after two weeks' submersion in water at 70 degrees Fahrenheit (21 degrees Centigrade), and be protected by a slow-burning, tough-braided outer-covering.

Where exposed to moisture and mechanical injury (as for use on decks, holds and fire-rooms) each stranded conductor shall have a solid insulation, to be approved, of at least one thirty-second of an inch in thickness and protected by a tough braid. The two conductors shall then be stranded together, using a jute filling. The whole shall then be covered with a layer of flax, either woven or braided, at least one thirty-second of an inch in thickness and treated with a non-inflammable, waterproof compound. After one week's submersion in water at 70 degrees Fahrenheit (21 degrees Centigrade), it must show an insulation between the two conductors, or between either conductor and the ground, of fifty megohms per mile.

93. Bell or Other Wires.

a. Must never be run in same duct with lighting or power wires.

94. Table of Allowable Capacity of Wires.

B. & S. G.	Area Actual C. M.	No. of Strands	Size of Strands B. & S. G.	Amperes.
19	1,288	...	..	...
18	1,624	...	..	3
17	2,048	...	..	...
16	2,583	...	..	6
15	3,257	...	..	...
14	4,107	...	..	12
12	6,530	...	..	17
..	9,016	7	19	21
..	11,368	7	18	25
..	14,336	7	17	30
..	18,081	7	16	35
..	22,799	7	15	40
..	30,856	19	18	50
..	38,912	19	17	60
..	49,077	19	16	70
..	60,088	37	18	85
..	75,776	37	17	100
..	99,064	61	18	120
..	124,928	61	17	145
..	157,563	61	16	170
..	198,677	61	15	200
..	250,527	61	14	235
..	296,387	91	15	270
..	373,737	91	14	320
..	413,639	127	15	340

When greater conducting area than that of 12 B. & S. gage is required, the conductor shall be stranded in a series of 7 19, 37, 61, 91 or 127 wires, as may be required; the strand consisting of one central wire, the remainder laid around it concentrically, each layer to be twisted in the opposite direction from the preceding.

95. Switchboard.

a. Must be made of non-combustible, non-absorptive, insulating material, such as marble or slate.

b. Must be kept free from moisture, and must be located so as to be accessible from all sides.

c. Must have a main switch, main cut-out and ammeter for each generator.

Must also have a voltmeter and ground detector.

d. Must have a cut-out and switch for each side of each ircuit leading from the board.

e. Must be wired with conductors having an insulation as equired for moulding or conduit work and covered with a ubstantial flameproof braid.

6. Resistance Boxes.

(For construction rules, see No. 78.)

a. Must be located on switchboard or away from cum- ustible material. When not placed on switchboard they must e mounted on non-inflammable, non-absorptive, insulating naterial.

7. Switches.

(For construction rules, see No. 65.)

a. When exposed to dampness, they must be enclosed in water-tight case.

b. Must be of the knife pattern when located on switch- oard.

c. Must be provided so that each freight compartment nay be separately controlled.

8. Cut-Outs.

(For construction rules, see No. 67.)

a. Must be placed at every point where a change is made n the size of the wire (unless the cut-out in the larger wire vill protect the smaller).

b. In such places as upper decks, holds, cargo spaces and ire-rooms, a water-tight and fireproof cut-out may be used, onnecting directly to mains when such cut-out supplies cir- uits requiring not more than 660 watts energy.

c. When placed anywhere except on switchboards must e enclosed in a cabinet lined with fire-resisting material.

d. Except for motors, searchlights and diving lamps must e so placed that no group of lamps, requiring a current of nore than 660 watts, shall ultimately be dependent upon one ut-out.

99. Fixtures.

a. Must be mounted on blocks made from well-seasoned lumber treated with two coats of white paint or shellac.

b. Where exposed to dampness, the lamp must be surrounded by a vapor-proof globe.

c. Where exposed to mechanical injury, the lamp must be surrounded by a globe protected by a stout wire guard.

d. Must be wired with same grade of insulation as portable conductors which are not exposed to moisture or mechanical injury.

e. Ceiling fixtures over two feet in length must be provided with stay chains.

100. Sockets.

(For construction rules, see No. 72.)

101. Wooden Mouldings.

(For construction rules, see No. 60.)

a. Where moulding is run over rivets, beams, etc., a backing strip must first be put up and the moulding secured to this.

b. Capping must be secured by brass screws.

102. Interior Conduits.

(For construction rules, see No. 58.)

a. No conduit tube having an internal diameter of less than five-eighths of an inch shall be used. Measurements to be taken inside of metal conduits.

b. Must be continuous from outlet to outlet or to junction boxes, and the conduit must properly enter and be secured to all fittings, and the entire system must be mechanically secured in position.

In case of main runs, this involves running each conduit continuously into a main cut-out cabinet or gutter surrounding the panel board, as the case may be.

c. Must be first installed as a complete conduit system, *without* the conductors.

d. Must be equipped at every outlet with an *approved* outlet box or plate.

Outlet plates must not be used where it is practicable to install outlet boxes.

The outlet box or plate must be so installed that it will be flush with the finished surface, and if this surface is broken it shall be repaired so that it will not show any gaps or open spaces around the edge of the outlet box or plate.

In vessels already constructed where the conditions are such that neither outlet box nor plate can be installed, these appliances may be omitted by special permission of the Inspection Department having jurisdiction, providing the conduit ends are bushed and secured.

It is suggested that outlet boxes and fittings having conductive coatings be used in order to secure better electrical contact at all points throughout the conduit system.

e. Metal conduits where they enter junction boxes, and at all other outlets, etc., must be provided with *approved* bushings fitted so as to protect wire from abrasion, except when such protection is obtained by the use of *approved* nipples, properly fitted in boxes or devices.

f. Must have the metal of the conduit permanently and effectually grounded.

Conduits must be securely fastened in metal outlet boxes so as to secure good electrical connection. If conduit, couplings, outlet boxes or fittings having protective coating of non-conducting material, such as enamel, are used, such coating must be thoroughly removed from threads of both couplings and conduit and from surfaces of boxes and fittings where the conduit is secured in order to obtain the requisite good connection. Where boxes used for centers of distribution do not afford good electrical connection, the conduits must be bound around them by suitable bond wires. Where sections of metal conduit are installed without being fastened to the metal structure of vessels or grounded metal piping, they must be bonded together and joined to a permanent and efficient ground connection.

Connections to grounded pipes and to conduit must be exposed to view or readily accessible, and must be made by means of approved ground clamps to which the ground wires must be soldered.

Ground wires must be of copper, at least No. 10 B. & S. gage (where largest wire contained in conduit is not greater

than No. o B. & S. gage), and need not be greater than No. 4 B. & S. gage (where largest wire contained in conduit is greater than No. o B. & S. gage). They shall be protected from mechanical injury.

g. Junction boxes must always be installed in such a manner as to be accessible.

h. All elbows or bends must be so made that the conduit or lining of same will not be injured. The radius of the curve of the inner edge of any elbow not to be less than three and one-half inches. Must have not more than the equivalent of four-quarter bends from outlet to outlet, the bends at the outlets not being counted.

103. Signal Lights.

a. Must be provided with *approved* telltale board, located preferably in pilot house, which will immediately indicate a burned-out lamp.

104. Motors.

a. Must be wired under the same precautions as with a current of same volume and potential for lighting. The motor and resistance box must be protected by a double-pole cut-out and controlled by a double-pole switch, except in cases where one-quarter horse power or less is used.

The motor leads or branch circuits must be designed to carry a current at least 25 per cent greater than that for which the motor is rated. Where the wires under this rule would be overfused, in order to provide for the starting current, as in the case of many of the alternating current, motors, the wires must be of such size as to be properly protected by these larger fuses.

b. Must be thoroughly insulated. Where possible, should be set on base frames made from filled, hard, dry wood and raised above surrounding deck. On hoists and winches they must be insulated from bed-plates by hard rubber, fiber or similar insulating material.

c. Must be covered with a waterproof cover when not in use.

d. Must each be provided with a name-plate giving maker's name, the capacity in volts and amperes, and the normal speed in revolutions per minute.

. Insulation Resistance.

The wiring in any vessel must test free from grounds; *i. e.*, complete installation must have an insulation between conductors and between all conductors and the ground (not including attachments, sockets, receptacles, etc.), of not less than following:—

Up to	25	amperes	800,000 ohms.
Up to	50	amperes	400,000 ohms.
Up to	100	amperes	200,000 ohms.
Up to	200	amperes	100,000 ohms.
Up to	400	amperes	50,000 ohms.
Up to	800	amperes	25,000 ohms.
Up to	1,600	amperes	12,500 omhs.

All cut-outs and safety devices in place in the above.
Where lamp sockets, receptacles and electroliers, etc., are nected, one-half of the above will be required.

USEFUL INFORMATION.

RESUSCITATION FROM ELECTRIC SHOCK.

Rules Recommended by

COMMISSION ON RESUSCITATION FROM ELECTRIC SHOCK

Representing

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The National Electric Light Association
The American Institute of Electrical Engineers

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Follow These Instructions Even if Victim Appears Dead.

I. IMMEDIATELY BREAK THE CIRCUIT.

With a single quick motion, free the victim from the current. Use any dry non-conductor (clothing, rope, board) to

Figure 206.

TABLE II.—WIRING TABLE FOR 1% LOSS.

Lights in Amperes. Voltage.				B. & S. Gauge	Car. Cap.	Motors in H. P. Voltage.				Ft. in 1-f load.
52	110	220	440			110	220	440	550	
98	209	418	836	14	12	28	112	448	579	.002628
124	263	526	1052	13	.....	35	140	560	724	.002084
158	333	666	1332	12	17	44	176	704	910	.001653
200	420	840	1680	11	.....	56	224	896	1159	.001311
250	529	1058	2116	10	24	70	280	1120	1449	.001040
314	665	1330	2660	9	.....	88	352	1408	1821	.000824
397	841	1682	3364	8	33	112	448	1792	2318	.000654
501	1060	2120	4240	7	.....	141	564	2256	2918	.000519
634	1338	2676	5352	6	46	178	712	2848	3684	.000411
798	1687	3374	6748	5	54	224	896	3584	4636	.000326
1000	2124	4248	8496	4	65	283	1132	4528	5858	.000259
1271	2683	5366	10732	3	76	357	1428	5712	7389	.000205
1595	3374	6748	13496	2	90	449	1796	7184	9294	.000163
2011	4264	8527	17054	1	107	568	2272	9088	11757	.000129
2543	5392	10784	21568	0	127	718	2872	11488	14702	.000102
3228	6790	13580	27160	00	150	905	3620	14480	18733	.000081
4053	8594	17188	34376	000	177	1145	4580	18320	23701	.000064
5090	10784	21568	43136	0000	210	1437	5748	22992	29745	.000051
6032	12790	25580	51160	250000	235	1696	6784	27136	35107	.0000431
7222	15277	30554	61108	300000	270	2036	8144	32576	42145	.000036
8441	17857	35714	71428	350000	300	2368	9472	37888	49017	.0000308
9629	20370	40740	81480	400000	330	2714	10856	43424	56179	.000027
10833	22916	45832	91664	450000	360	3054	12216	48864	63217	.000024
12093	25581	51162	102324	500000	390	3393	13572	54288	70235	.0000215
24074	50925	101850	203700	1000000	650	6786	27144	108576	140470	.0000108
48148	101851	203702	407404	2000000	1050	13572	54292	217168	280941	.0000054

Figure 207.

TABLE IV.—WIRING TABLE FOR 3% LOSS.

Lights in Amperes. Voltage.				B. & S. Gauge.	Car. Cap.	Motors in H. P. Voltage.				Resis. per foot.
52	110	220	440			110	220	440	500	
294	627	1254	2508	14	12	84	336	1344	1737	.002628
372	789	1578	3156	13	.....	105	420	1680	2172	.002084
474	999	1998	3996	12	17	132	528	2112	2730	.001653
600	1260	2520	5040	11	.....	168	672	2688	3477	.001311
750	1587	3174	6348	10	24	210	840	3360	4347	.001040
942	1995	3990	7980	9	.....	264	1056	4224	5463	.000824
1191	2523	5046	10092	8	33	336	1344	5376	6954	.000654
1503	3180	6360	12720	7	.....	423	1692	6768	8754	.000519
1902	4014	8028	16056	6	46	534	2136	8544	11052	.000411
2394	5061	10122	20244	5	54	672	2688	10752	13808	.000326
3000	6372	12744	25488	4	65	849	3396	13584	17574	.000259
3813	8049	16098	32196	3	76	1071	4284	17136	22167	.000205
4785	10122	20244	40458	2	90	1347	5388	21552	27882	.000163
6033	12792	25581	51162	1	107	1704	6816	27264	35271	.000129
7629	16176	32352	64704	0	127	2154	8616	34464	44286	.000102
9684	20370	40740	81480	00	150	2715	10860	43440	56199	.000081
12059	25782	51564	103128	000	177	3435	13740	54960	71103	.000064
15270	32352	64704	129408	0000	210	4311	17244	68976	89235	.000051
18096	38370	76740	153480	250000	235	5088	20352	81408	105321	.0000431
21666	45831	91662	183324	300000	270	6108	24432	97728	126435	.000036
25323	53571	107142	214284	350000	300	7104	28416	113664	147051	.0000308
28887	61110	122220	244440	400000	330	8142	32568	130372	168537	.000027
32499	68748	137496	274992	450000	360	9162	36648	146592	189651	.000024
36279	76743	153486	306972	500000	390	10179	40716	162864	210705	.0000215
72222	152775	305550	611100	1000000	650	20358	81432	325728	421410	.0000108
144444	305553	611106	1222212	2000000	1050	40719	162876	651504	842883	.0000054

A test for "ground" may be made in the same way, but the lamp must be connected to both sides in turn and the fuse left out. If the main system to which the circuit to be tested connects is not grounded, a temporary ground must be put on. This is best done by connecting a lamp with one wire to a gas or water pipe and the other to the "live" binding screw on the opposite side of cutout to that in which the other lamp is connected. Thus, in Figure 208, if a ground should exist at 3 and

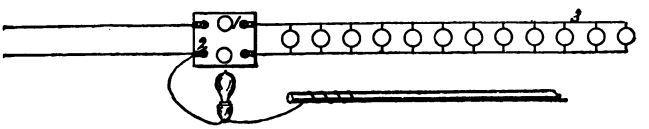

Figure 208.

the lamp be connected to gas pipe, as shown, the test lamp at 1 would burn.

If a voltmeter were connected in place of either of the lamps, the test would be much more searching.

With 3-wire systems no ground need be put on, as the neutral wire will always be found grounded. The lamp need be tried in the outside fuses only. This test will be more searching if lamps are placed in all sockets connected.

In placing fuses in the 3-wire, 110-220 volt system, the neutral wire should always be fused first.

By reference to Figure 209 it will be seen that while the neutral fuse in main blocks *a* is out, the two circuits of lamps *c* and *d* must burn in series; that is, just as much current must pass through one circuit as through the other. So long as there is an equal number of lamps in each circuit there is no trouble; but should most of the lamps in one circuit be turned off, those remaining would have to carry all the current that passes through the lamps of the other circuit. This current

would overheat them and break, or burn them out in a very short time. If the neutral fuse is in place, each circuit is independent of the other and the neutral wire only carries the difference in current between the two sets of lamps. In order to insure against a neutral fuse "blowing" first in case of trouble, it is generally made heavier than in the outside wires. When a 3-wire circuit is to be cut off, the outside fuses should be drawn first.

In order to find which is the "neutral" wire, two 110 volt lamps are connected in series and the wires from them brought in contact with two of the three wires. If both lamps burn at full candle power we have 220 volts, which is the pressure of the outside wires, and, therefore, the other wire must be the

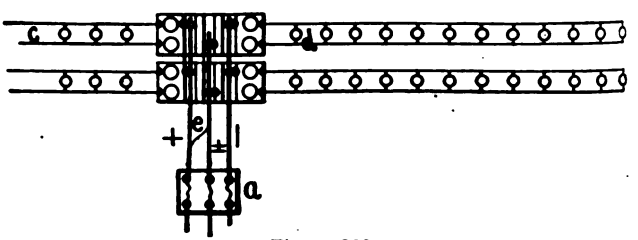

Figure 209.

neutral. If the lamps burn only at half candle power, we have only 110 volts and one of the wires must be the neutral. That wire which gives 110 volts with either one of the other two wires is the neutral; this wire should always be run in the center between the other two.

A test for the neutral wire can also be made by connecting a lamp to ground. A lamp connected this way will burn from either of the outside wires, but not from the neutral.

If the neutral wire should be connected to any but the middle binding post of 3-wire cutouts and the outside wire made. (See Section 1.)

to the other two, one-half of the lamps would be almost immediately destroyed, being subject to 220 volts, while the other half would burn properly.

If a short circuit occurs, say at *e*, Figure 209, on one side of a 3-wire system and blows the neutral fuse on that side of the circuit, we shall have 220 volts on the lamps on the opposite side. This will quickly burn them out. Most of these troubles are avoided to some extent by the use of such branch cutouts as shown. This confines trouble of this kind to the mains.

On any system having a neutral wire or a wire on one side grounded, if a ground on either of the other wires occurs, the trouble can be temporarily remedied by simply changing the two wires of that circuit at the cutout. This will transfer the ground to the side already grounded, so that it will not interfere with operation. The ground must, however, be cleared up at once as no grounding is ever allowed inside of any building.

When strip cutouts are set horizontally and there is no bridge between opposite polarities, there will be the possibility of a partially melted upper fuse sagging down and forming a short circuit.

On panel boards where fuses are set too close together, the heat of one fuse while blowing will often blow the next fuse above it.

If large fuses are enclosed in small and very tight cabinets, the vapors formed by blowing will often cause short circuits.

Before installing fuses in a "loaded" circuit, it is advisable to disconnect as many lights and other devices as possible. If there is a main switch this can easily be done. If there is no such switch on that part of the system, the task of placing fuses is somewhat hazardous; for at the very instant that the second fuse touches its terminal a great rush of current will

flow. If there happens to be a "short" on the line both fuses will probably blow and may burn the operator's hands and face severely. In order to avoid this, extremely careful manipulation is necessary. The first fuse can be placed without any difficulty, as there will be no current flow unless the circuits are grounded. Before attempting to place the second fuse the circuits may be tested for "shorts" by placing a "jumper" (a piece of wire heavy enough so that it will not be heated by the current it is to carry) with the ends on the other fuse terminals. This "jumper" will complete the circuit and, if all is in order the lights will burn. If there are two men, one may hold the jumper while the other places the fuse, but it should be placed as quickly as possible, especially if the circuit has a motor load, for these will be started very soon after the lights come on and will greatly increase the current. If there is but one man the jumper may be temporarily fastened to the mains.

A jumper is not absolutely necessary even with large fuses, for if the last contact is made quickly and held steady, there will be very little arcing; one should, however, provide all protection possible. If a piece of asbestos is at hand, it may be used to cover the fuses, so as to protect the hands and face from melted metal.

Before attempting to re-fuse a circuit, note condition of cutout block. If there is evidence of a great flash, it is very likely that the fuse was blown by a short circuit. If the blowing was caused by a slight overload or loose contact, the destructive effect will be much less.

Much trouble can be prevented by cleaning terminals of fuse blocks occasionally and going over nuts and screws to see that they are tight.

In Figure 210, *a* shows the proper way of connecting small wires into such terminals. This method prevents the screw from cutting into the main wire and allowing it to break.

DIMENSIONS OF COPPER WIRE

Numbers B. & S. Gauge	Diameters in Mils.	Areas in circular Mils. C.M.—d²	Weights		Ohms per 1000 feet
			1000 feet	Mile	
0000	460.	211,600.	641.	3,382.	.051
000	410.	168,100.	509.	2,687.	.064
00	365.	133,225.	403.	2,129.	.081
0	325.	105,625.	320.	1,688.	.102
1	289.	83,521.	253.	1,335.	.129
2	258.	66,564.	202.	1,064.	.163
3	229.	52,441.	159.	838.	.205
4	204.	41,616.	126.	665.	.259
5	182.	33,124.	100.	529.	.326
6	162.	26,244.	79.	419.	.411
7	144.	20,736.	63.	331.	.519
8	128.	16,384.	50.	262.	.654
9	114.	12,996.	39.	208.	.824
10	102.	10,404.	32.	166.	1.040
11	91.	8,281.	25.	132.	1.311
12	81.	6,561.	20.	105.	1.653
13	72.	5,184.	15.7	83.	2.084
14	64.	4,096.	12.4	65.	2.628
15	57.	3,249.	9.8	52.	3.314
16	51.	2,601.	7.9	42.	4.179
17	45.	2,025.	6.1	32.	5.269
18	40.	1,600.	4.8	25.6	6.645
19	36.	1,296.	3.9	20.7	8.617
20	32.	1,024.	3.1	16.4	10.566
21	28.5	812.3	2.5	13.	13.283
22	25.3	640.1	1.9	10.2	16.85
23	22.6	510.8	1.5	8.2	21.10
24	20.1	404.	1.2	6.5	26.70
25	17.9	320.4	.97	5.1	33.67
26	15.9	252.8	.77	4.	42.68
27	14.2	201.6	.61	3.2	53.52
28	12.6	158.8	.48	2.5	67.84
29	11.3	127.7	.39	2.	84.49
30	10.	100.	.3	1.6	107.3
31	8.9	79.2	.24	1.27	136.2
32	8.	64.	.19	1.02	168.5
33	7.1	50.4	.15	.81	214.0
34	6.3	39.7	.12	.63	271.7
35	5.6	31.4	.095	.5	343.6
36	5.	25.	.076	.4	431.6

table below, find the same number in the first column; divide the diameter of cable by the number set opposite this in the second column. This will give the diameter of each wire. Multiply this diameter by itself and then by the number of wires contained in cable as given in the third column. All measurements should be expressed in mils (1/1,000 inch) and the result will be the circular mils contained in cable.

Outside layer	6 wires	3 times diameter	7 wires in cable
Outside layer	12 wires	5 times diameter	19 wires in cable
Outside layer	18 wires	7 times diameter	37 wires in cable
Outside layer	24 wires	9 times diameter	61 wires in cable
Outside layer	30 wires	11 times diameter	91 wires in cable
Outside layer	36 wires	13 times diameter	127 wires in cable
Outside layer	42 wires	15 times diameter	169 wires in cable

The various figures in Figure 211 are designed to show how many single wires may be run in one conduit. Under each figure is given a number which, if multiplied by the diameter of the wire to be used will give the smallest diameter of tube which can contain the corresponding number of wires. Thus, for instance, if 12 wires are run through one tube or conduit, the diameter of that conduit must be at least 4 1/3 times as great as the diameter of the wire to be used. Each figure illustrates the amount of spare room the corresponding number of wires leave, and it is necessary to use considerable judgment. Long runs will require more space, especially if the wires be quite large. Much also depends upon the nature of the insulation and the temperature. The figures are believed to be correct for single wires and can be followed for twin wires, as the same number of conductors arranged that way will not occupy as much space as single wires. The actual diameter of lined and unlined conduits are given in another table and may be referred to. The best way to accurately determine the diameter of small wire consists in cutting a number of short pieces and laying them together, then measuring over all and dividing the measurement by the number of wires.

2 WIRES
2 TIMES DIAM.
3 WIRES
2½ TIMES DIAM.
4 WIRES
2½ TIMES DIAM.
5 WIRES
2½ TIMES DIAM.
6 or 7 WIRES
3 TIMES DIAM.
8 WIRES
3½ TIMES DIAM.
9 WIRES
3½ TIMES DIAM.
10 WIRES—4 TIMES DIAM.
16 WIRES
4½ TIMES DIAM.
14 WIRES
4½ TIMES DIAM.
12 WIRES
4½ TIMES DIAM.
11 WIRES
4½ TIMES DIAM
19 WIRES
5 TIMES DIAM.
22 WIRES
5⅛ TIMES DIAM.
25 WIRES
6 TIMES DIAM.
31 WIRES
6½ TIMES DIAM

Figure 211.

TRICKS OF THE TRADE.

Cases have been known where it was requested to replace single pole switches by double pole, that the single pole switch was replaced as requested, but, instead of running both wires through it as required, only one wire had been properly brought into it and the other two binding posts filled out with short pieces of wire calculated to deceive the inspector. A test to detect this without disconnecting the swtich is easily made. By reference to Figure 212 it will be seen that if a double pole snap switch is properly connected, current can be felt if the points *a* and *b* are touched with moistened fingers. If the switch is connected single pole, current can be felt at *b* and *c*, when the switch is open, only.

On one occasion a wireman had run some wires on insulators along a ceiling and instead of soldering joints had carefully, in many places above the joints, smoked the ceiling with a candle in order to deceive an inspector.

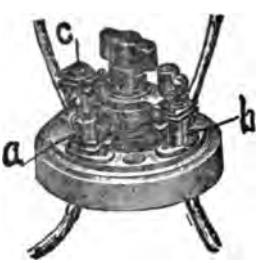

Figure 212.

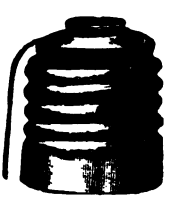

Figure 213.

In several cases where an "over-all" test of insulation resistance was made, meter loops which had been run in continuous pieces were found with the wire "nicked" with a knife and then broken, leaving the insulation nearly intact, but the

circuit open. A similar trick is often worked with the ground wire of ground detectors.

In other cases plugs with fuses removed were put in "bad" circuits. In one case the real circuit wires (concealed work) were disconnected from cutouts and pushed back into the wall and short pieces connected instead.

In another case where wire not up to requirements had been used and condemned, this wire, being run between joists and concealed by plastering, was pushed back and short pieces of approved wire stuck in at outlets.

Sometimes in fished work after inspection the long pieces of loom reaching from outlet to outlet are withdrawn and short pieces at the outlets substituted.

Lamp butts with wire terminals twisted together, or a strand of wire from lamp cord twisted around the base as shown in Figure 213 and screwed into the cutout are often used in place of fuses. The strand of cord is sometimes used to help out a fuse plug on an overloaded circuit.

METER CONNECTIONS.

Figures 214 to 216 show method of making meter connections in apartment buildings. Figure 214 shows connections for apartments where only one circuit is used for each apartment. In this case the meter is connected in the branch circuits after they leave their respective cutout blocks. While only three meters are shown in the figure any number of apartments could be connected in the same manner.

Figures 215 and 216 show connections where two or more circuits are used in each apartment. Each meter leg is fused where it connects to the mains. After leaving the meter the main feeding the apartment is carried to the branch cutout blocks of which there can be any number. The design shown in Figure 216 is especially applicable to apartment buildings as a number of meters can be placed in a location where there is little head room as in the ordinary basement.

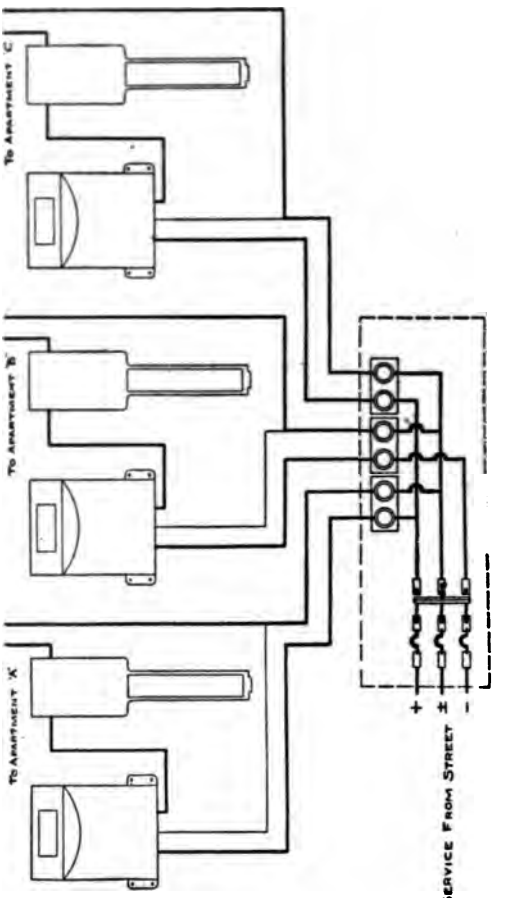
To Apartment 'C'
To Apartment 'B'
To Apartment 'A'
+
±
-
Service From Street

Figure 214.

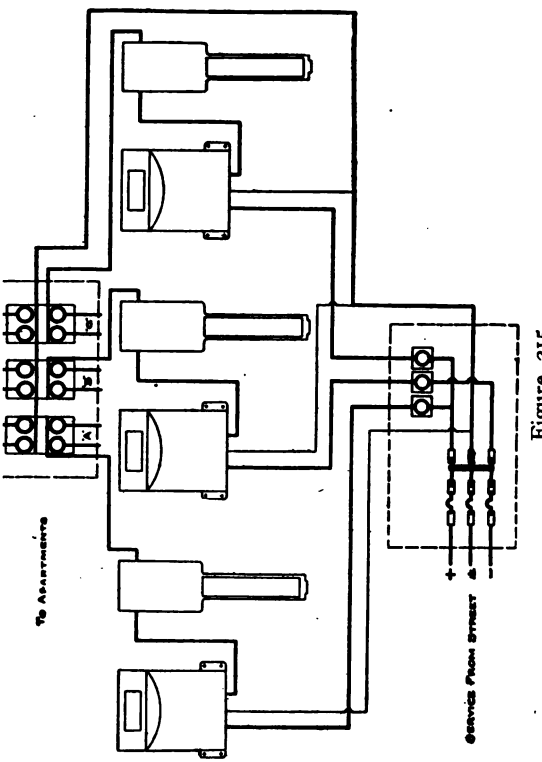

Figure 215.

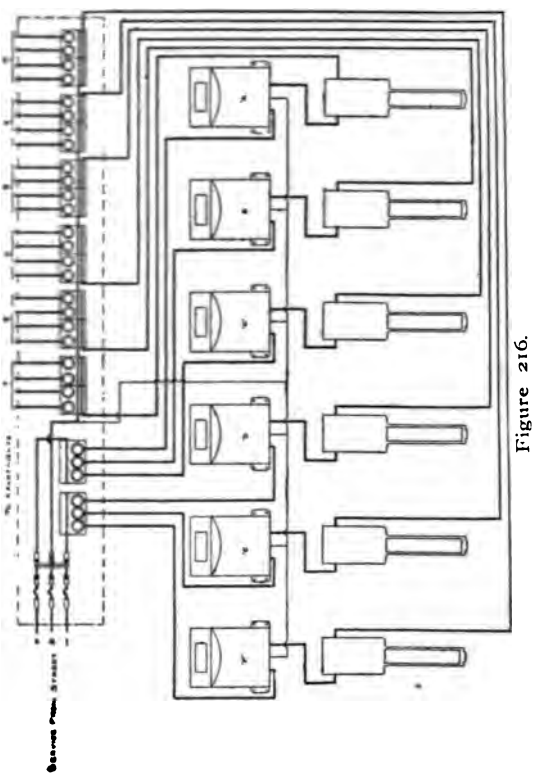

Figure 216.

le of Carrying Capacity of Wires.

The following table, showing the allowable carrying ca-ty of copper wires and cables of ninety-eight per cent con-ivity, according to the standard adopted by the American itute of Electrical Engineers, must be followed in placing rior conductors.

›r insulated aluminum wire the safe carrying capacity is eighty- per cent of that given in the following tables for copper wire the same kind of insulation.

TABLE NO. I.

B. & S. G.	Table A. Rubber Insulation. Amperes.	Table B. Other Insulations. Amperes.	Circular Mils.
18	3	5	1,624
16	6	8	2,583
14	12	16	4,107
12	17	23	6,530
10	24	32	10,380
8	33	46	16,510
6	46	65	26,250
5	54	77	33,100
4	65	92	41,740
3	76	110	52,630
2	90	131	66,370
1	107	156	83,690
0	127	185	105,500
00	150	220	133,100
000	177	262	167,800
0000	210	312	211,600
Circular Mils.			
200,000	200	300	
300,000	270	400	
400,000	330	500	
500,000	390	590	
600,000	450	680	
700,000	500	760	
800,000	550	840	
900,000	600	920	
1,000,000	650	1,000	
1,100,000	690	1,080	
1,200,000	730	1,150	
1,300,000	770	1,220	
1,400,000	810	1,290	
1,500,000	850	1,360	
1,600,000	890	1,430	
1,700,000	930	1,490	
1,800,000	970	1,550	
1,900,000	1,010	1,610	
2,000,000	1,050	1,670	

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